

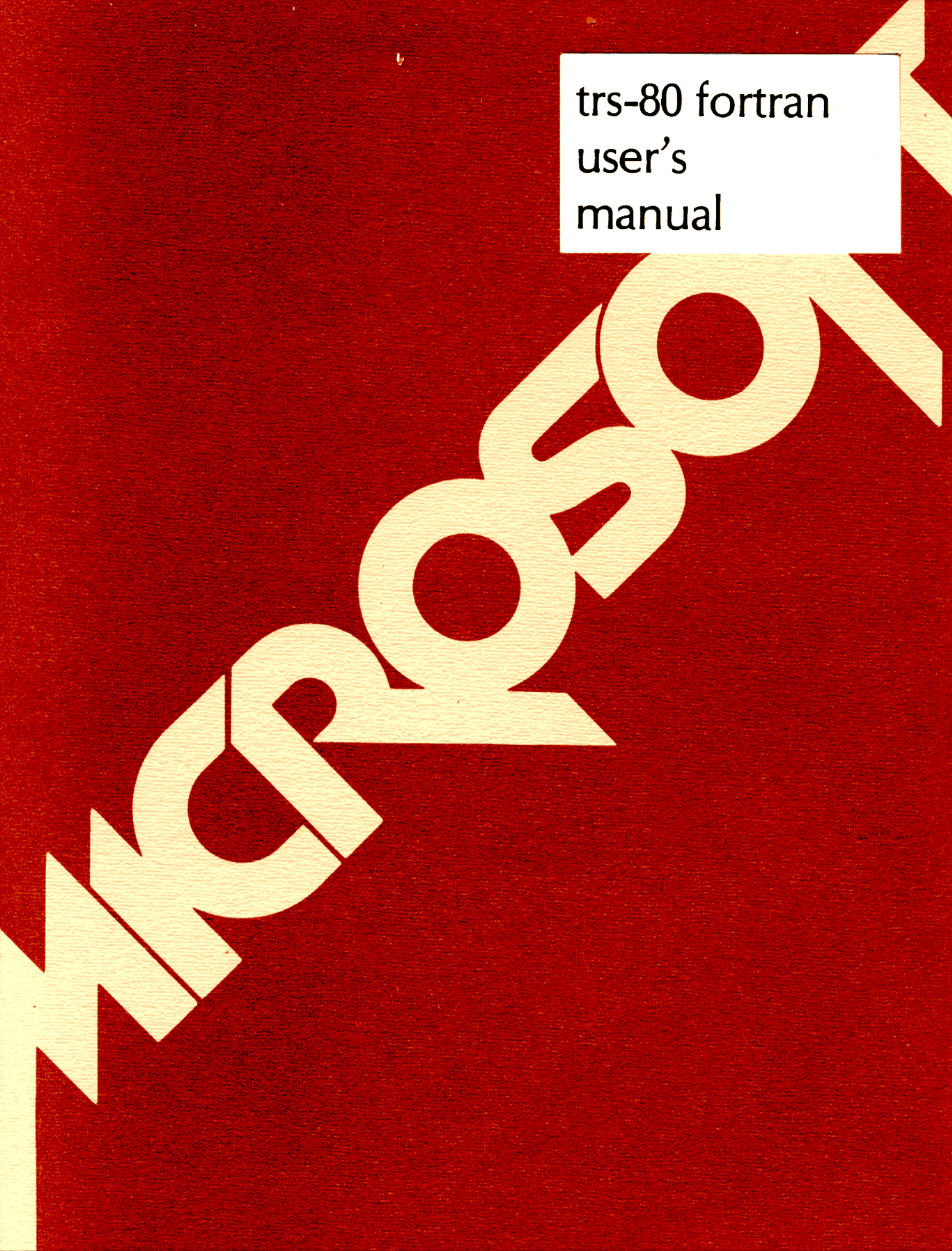
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Bellevue, WA
98004

trs-80 fortran
user's
manual



trs-80 fortran user's manual

Microsoft FORTRAN-80
for the Radio Shack TRS-80
Model I Computer

Microsoft Consumer Products
400 108th Ave. NE, Suite 200
Bellevue, WA 98004

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TRS-80 FORTRAN

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ADDENDA
TRS-80 FORTRAN

General

TRSDOS Problems

There are two bugs in version 2.3 TRSDOS which may sometimes cause problems with Microsoft's FORTRAN compiler or EDIT-80 text editor. These bugs should be corrected in future versions of TRSDOS, but until those corrections occur, use the following methods to circumvent the problems.

1. Files with record lengths of less than 256 bytes will sometimes not be accessed properly. The usual symptoms are "End of File" or "Record Number Out of Range" errors, or occasionally you may not be able to access the last sector of the file.

If you encounter this problem while running a FORTRAN program which accesses disk files, increase the record length of the file (or files) to 256.

2. The TRSDOS "COPY" utility will not correctly copy files created with EDIT-80. This problem may be easily avoided by using EDIT-80 itself to copy the files. For example, if you wish to copy TEMP/FOR from drive 0 to drive 1, do the following:

```
EDIT TEMP/FOR:0
```

```
.
```

```
.
```

```
*E TEMP/FOR:1
```

NOTE: Do not ever switch diskettes while editing a file. The editor creates the new file by reading from the old one.

Regarding TRSDOS

Note that TRSDOS was not written by Microsoft. Any questions regarding the TRSDOS operating system or utilities should be addressed to Radio Shack. Inquiries regarding TRSDOS updates should also be addressed to Radio Shack.

Swapping Diskettes

The only safe times to swap diskettes are:

1. Before booting TRSDOS
2. When currently at TRSDOS command level ("DOS READY" prompt)
3. When currently at command level in F80 or L80 ("*" prompt)
4. When EDIT prompts for a filename ("FILE:")

Swapping diskettes at other times may cause lost data and/or lost files.

In particular, it is NOT safe to switch diskettes during an EDIT session after the file name has been specified.

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Microsoft
TRS-80 FORTRAN
User's Manual

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SECTION 1

Introduction

The purpose of this TRS-80 FORTRAN User's Manual is to give you practical information about getting a FORTRAN-80 program up and running on your TRS-80 computer. All the steps necessary to use FORTRAN-80 successfully -- compiling, loading, executing, etc. -- are described in the following pages.

1.1 Distribution Disks

The FORTRAN-80 diskettes you receive from Microsoft (labelled FORTRAN 1 and FORTRAN 2) contain the following files:

FORTRAN 1:

FORTRAN-80 Compiler
TRSDOS Operating System

FORTRAN 2:

FORLIB/REL FORTRAN-80 Subroutine Library
LINK-80 Linking Loader
EDIT-80 Text Editor
TRSDOS Operating System

The distribution disks are write-protected.

We recommend that you immediately make back-up copies of both diskettes using the TRSDOS Backup utility, which is on both diskettes.

1.2 Program Development Steps

The three major steps in developing a FORTRAN program are:

- Compiling the program
- Loading the program
- Executing the program

These steps are described further in Sections 2 through 5 of this manual. However, to give you an overall view of the FORTRAN-80 system and an idea of a typical program development session, the following sample session is provided. We recommend that you perform all the steps in this sample program development session. It contains tips that will help you make the most efficient use of your FORTRAN-80 software.

The sample session assumes that your system has at least two disk drives. Typically, you will have one of the Microsoft distribution diskettes in one drive and your "work" diskette in the other. It doesn't matter which diskette you put in "drive 0" or "drive 1." We use these designations in the Sample Session for convenience only.

If you have a single-drive system, you can still use TRS-80 FORTRAN, but you must do a lot of disk-swapping. Follow the sample session given in Appendix A for single-drive systems.

A FORTRAN program is provided in Figure 1 for use during the sample session. Before beginning STEP 1, you should be at TRSDOS command level.

SAMPLE SESSION

STEP 1: Place the FORTRAN 2 diskette in drive 1 and a formatted "work" diskette in drive 0. Enter the command:

EDIT

This loads the EDIT-80 text editor.
EDIT-80 will respond with

FILE:

If you are using the program in Figure 1, type the filename TEMP/FOR followed by the <break> key. If you are using your own FORTRAN program, type any legal TRSDOS filename. Always follow the filename with

<break> when creating a new file and with
<enter> when reading in an existing file.

After EDIT-80 prints the message:

```
Creating
Version x.x
Copyright 1977,78 (c) by Microsoft
Created: xxxx
xxxx Bytes free
*
```

enter the command:

I

EDIT-80 will print 00100, which is the first line number, followed by a tab. The cursor is now in "column 1" and you are ready to begin entering your FORTRAN program.

STEP 2: Start entering the FORTRAN program as listed in Figure 1 (or enter your own FORTRAN program). EDIT-80 will type the next line number each time you <enter> a line.

While you're typing in your program, all of EDIT-80's editing capabilities are available to you. Read through the EDIT-80 User's Guide. You'll see how easy it is to insert and delete lines, modify text, and search for text. This is a good chance to experiment with EDIT-80.

When writing any FORTRAN program for your TRS-80, use the Microsoft FORTRAN-80 Reference Manual to determine the correct syntax and usage of all FORTRAN statements.

STEP 3: When you are finished typing in the program, type a <break> after the next available line number to return to EDIT-80 command level. To exit the editor, enter the command:

E

Now there is a FORTRAN program called TEMP/FOR on the work disk. This program is the source file.

- STEP 4: Syntax check.
Before proceeding, it is a good idea to check the program for syntax errors. Removing syntax errors now eliminates a possible recompilation later. To perform the syntax check on the source file called TEMP/FOR, place the diskette labelled FORTRAN 1 in drive 1 and type:

```
F80 TEMP
```

This command runs the FORTRAN compiler and compiles the source file without producing an object or listing file (more on object and listing files in STEP 5). If there are errors, run EDIT-80 again (STEP 1) and correct them. The FORTRAN compiler error messages are listed in Section 2.4.

- STEP 5: Compile the source file.
When the syntax check no longer generates errors, you are ready to compile the source file. To compile the source file called TEMP/FOR and produce an object and listing file, type the following:

```
F80 TEMP,TEMP=TEMP
```

This creates a relocatable object file called TEMP/REL and a listing file called TEMP/LST on the disk. REL and LST are the default extensions supplied by the compiler. The object file contains the machine-readable code generated by the compiler. The listing file contains the FORTRAN source program statements and the machine language generated by each statement. See Figure 2 for a copy of the listing file generated by TEMP.

- STEP 6: Load and execute the program.
To load the program into memory and execute it, put FORTRAN 2 in drive 1 and type:

```
L80 TEMP-G
```

This command loads TEMP/REL, links it with routines in FORLIB, and causes the program image in memory to be executed. Your program output should appear on the screen as shown in Figure 3.

During execution of your program, you may get a runtime error. Runtime errors are

listed in Section 5.1. If you get an error at runtime, it will be necessary to edit the source file (Step 1) to correct the error.

STEP 7: Save the object file.
Once your program executes without errors, you will want to save the executable file on disk. To do this, type:

L80 TEMP-N,TEMP-E

This command writes a copy of the executable object file to your work diskette under the name TEMP/CMD, and then exits to TRSDOS. The executable file may now be run by entering the command:

TEMP

at TRSDOS command level. For more information on LINK-80, see Section 4 of this manual.

FIGURE 1 FORTRAN SOURCE FILE

[illegible]

FIGURE 2 LISTING FILE TEMP/LST

```

1.  FORTRAN-80 VER. 3.2 COPYRIGHT 1978 (C) BY MICROSOFT
2.  BYTES: 3699
3.  CREATED: 15-FEB-79
4.  00100      C      CONVERT FAHRENHEIT TO CENTIGRADE
5.  00200      INTEGER F
6.  00300      WRITE(5,5)
7.  *****    0000'   LD      BC,$$L
8.  *****    0003'   JP      $INIT
9.  *****    0006'   LD      DE,5L
10. *****    0009'   LD      HL,[      05      00]
11. *****    000C'   CALL    $W2
12. 00400      5      FORMAT(33H      FAHRENHEIT      CENTIGRADE)
13. *****    000F'   CALL    $ND
14. 00500      DO 20 F=20,65,5
15. 00600      C=5./9.*(F-32)
16. *****    0012'   LD      HL,0014
17. *****    0015'   LD      (F),HL
18. 00700      WRITE(5,10)F,C
19. *****    0018'   LD      HL,(F)
20. *****    001B'   LD      DE,FFE0
21. *****    001E'   ADD     HL,DE
22. *****    001F'   LD      (T:000000),HL
23. *****    0022'   LD      HL,[      00      00      20      83]
24. *****    0025'   CALL    $L1
25. *****    0028'   LD      HL,[      00      00      10      84]
26. *****    002B'   CALL    $DB
27. *****    002E'   LD      HL,(T:000000)
28. *****    0031'   CALL    $MA
29. *****    0034'   LD      HL,C
30. *****    0037'   CALL    $T1
31. *****    003A'   LD      DE,10L
32. *****    003D'   LD      HL,[      05      00]
33. *****    0040'   CALL    $W2
34. 00800      10      FORMAT(12X,12,11X,F6.3)
35. *****    0043'   LD      DE,F
36. *****    0046'   LD      HL,[      01      00]
37. *****    0049'   LD      A,02
38. *****    004B'   CALL    $I0
39. *****    004E'   LD      DE,C
40. *****    0051'   LD      HL,[      01      00]
41. *****    0054'   LD      A,02
42. *****    0056'   CALL    $I1
43. *****    0059'   CALL    $ND
44. 00900      20      CONTINUE
45. 01000      END

```

-continued-

```

46. ***** 005C' LD HL, (F)
47. ***** 005F' LD DE, 0005
48. ***** 0062' ADD HL, DE
49. ***** 0063' LD A, 41
50. ***** 0065' SUB L
51. ***** 0066' LD A, 00
52. ***** 0068' SBC H
53. ***** 0069' JP P, 0015'
54. ***** 006C' CALL $EX
55. ***** 006F' 0100
56. ***** 0071' 0500
57. ***** 0073' 00002083
58. ***** 0077' 00001084
59.
60. PROGRAM UNIT LENGTH=007B (123) BYTES
61. DATA AREA LENGTH=0040 (64) BYTES
62.
63. SUBROUTINES REFERENCED:
64.
65. $I1 $I0 $INIT
66. $W2 $ND $L1
67. $DB $MA $T1
68. $EX
69.
70. VARIABLES:
71.
72. F 0001" C 0029" T: 000000
73.
74. LABELS:
75.
76. $$L 0006' 5L 0003" 20L 005C'
77. 10L 002F"
78.

```

FIGURE 3 TEMP/FOR PROGRAM OUTPUT

FAHRENHEIT	CENTIGRADE
20	-6.667
25	-3.889
30	-1.111
35	1.667
40	4.444
45	7.222
50	10.000
55	12.778
60	15.556
65	18.333

1.3 Note on TRS-80 FORTRAN Manuals

The FORTRAN-80 Reference Manual is strictly a reference for the syntax and semantics of the TRS-80 FORTRAN language. It is not intended as a tutorial on FORTRAN programming. If you are new to FORTRAN and need help learning the language, we suggest:

1. "FORTRAN IV, A Self-Teaching Guide" by Jehosua Friedmann, Philip Greenberg, and Alan M. Hoffberg (Wiley, 1975)
2. "Guide to FORTRAN-IV Programming" by Daniel McCracken (Wiley, 1965)
3. "Ten Statement FORTRAN Plus FORTRAN IV" by Michael Kennedy and Martin B. Solomon (Prentice-Hall, 1975, Second Edition)
4. "FORTRAN" by Kenneth P. Seidel (Goodyear, 1972)

SECTION 2

TRS-80 FORTRAN Compiler

If you followed the sample session, you are becoming familiar with the software in your TRS-80 FORTRAN package. Now let's look specifically at the TRS-80 FORTRAN compiler.

2.1 Running the Compiler

When you give TRSDOS the command

F80

(FORTRAN 1 must be in the disk drive), you are running the TRS-80 FORTRAN compiler. The FORTRAN compiler takes a FORTRAN source program and compiles it to generate a relocatable object program that consists of a series of machine language instructions and calls to the FORTRAN library. If directed, the compiler also creates a listing file consisting of your FORTRAN statements and the machine code generated from them. This listing file, unlike the REL (relocatable object) program, can be listed and printed from TRSDOS command level.

When the compiler is ready to accept commands, it prompts the user with an asterisk. To exit the compiler, use the <break> key.

A command may also be typed on the same line as the invocation. This is called a "command line." We did this in the Sample Session when we typed the command line:

F80 =TEMP

After executing a command line, the compiler automatically exits to the operating system.

2.2 Command Format

A compiler command conveys the name of the source file you want to compile, and what options you want to use. Here is the format for a compiler command (square brackets indicate optional):

```
[object filename][,listing filename]=source filename[-switch...]
```

NOTE

All filenames must be in TRSDOS filename format:

filename[/ext][.password][:drive#]. If you are using the compiler's default extensions, it is not necessary to specify an extension in a compiler command.

Let's look individually at each part of the compiler command:

1. Object filename

To create a relocatable object file, this part of the command must be included. It is simply the name that you want to call the object file. The default extension for the object filename is /REL.

2. Listing filename

To create a listing file, this part of the command must be included. It is simply the name that you want to call the listing file. The default extension for the listing file is /LST. The listing filename is always preceded by a comma in the compiler command.

3. Source filename

A compiler command must always include a source filename -- that is how the compiler "knows" what to compile. It is simply the name of a FORTRAN program you have saved on disk. The default extension for a FORTRAN source filename is /FOR. The source filename is always preceded by an equal sign in a compiler command.

Examples (asterisk is typed by F80):

* ,=TEST	Compile the program TEST/FOR without creating an object file or listing file. This is a fast way to check a program for syntax errors.
*TEST,TEST=TEST	Compile the program TEST/FOR. Create a relocatable object file called TEST/REL and a listing file called TEST/LST.
* ,TEST.PASS=TEST.PASS	Compile the program TEST/FOR.PASS and create a listing file called TEST/LST.PASS (No object file created.) Note the comma preceding TEST.PASS.
*TESTOBJ=TEST	Compile the program TEST/FOR and create an object file called TESTOBJ/REL. (No listing file created.).

4. Switch

A switch on the end of a command specifies a special action to be taken during compilation. Switches are always preceded by a dash (-). More than one switch may be used in the same command. The available switches are:

<u>Switch</u>	<u>Action</u>
O	Print all listing addresses in octal.
H	Print all listing addresses in hexadecimal (default condition).
N	Do not list the object code that is generated. List only the FORTRAN source code.
P	Each -P allocates an extra 100 bytes of stack space for use during compilation. Use -P if stack overflow errors occur during compilation. Otherwise not needed.
M	Specifies to the compiler that the generated code should be in a form which can be loaded into ROMs. (See also Appendix C.) When a -M is specified, the generated code will differ from normal in the following ways: <ol style="list-style-type: none">1. FORMATS will be placed in the program area, with a "JMP" around them.2. Parameter blocks (for sub-program calls with more than 3 parameters) will be initialized at runtime, rather than being initialized by the loader.

Examples:

- *CT.ME,CT.ME=CT.ME-O Compile CT/FOR.ME. Create a listing file called CT/LST.ME and an object file called CT/REL.ME. The addresses in the listing file will be in octal.
- *CT,CT=CT-N Compile the program CT/FOR. Create an object file called CT/REL and a listing file called CT/LST. The listing file will contain only FORTRAN source statements, not generated object code.
- *MAX10=MAX10-P-P Compile the program MAX10/FOR and create an object file called MAX10/REL. The compiler is allocated 200 extra bytes of stack space.

2.3 Input/Output Device Names

In the commands discussed so far, it is assumed that all files are read from and written to the disk. To use an I/O device other than the disk, specify the device name in place of the filename in the compiler command.

The device names supplied by TRSDOS are:

*KI	Keyboard Input
*DO	Display Output
*PR	Printer Output

(*DO and *PR are available only with TRSDOS Version 2.2 or later.)

Examples (first asterisk is typed by FORTRAN-80):

*TEST,*PR=TEST Compile the program TEST/FOR,
 Create an object file called
 TEST/REL and output the listing
 file, TEST/LST, at the printer.

*TEST,*DO=TEST-N Compile the program TEST/FOR.
 Create an object file called
 TEST/REL and output the listing
 file, TEST/LST at the video
 display. The listing file will
 only contain the FORTRAN source
 statements, not the generated
 object code.

==*KI *KI is used only if you want to
 input a source file from the
 keyboard. This command compiles
 the source file read from the
 keyboard without creating a REL or
 LST file.

,*DO=*KI This command puts the compiler in
 an interactive mode. Any FORTRAN
 statement typed at the keyboard
 will be displayed on the video
 display followed by the generated
 machine code. This can be very
 useful for finding errors in
 statement formats.

REMEMBER: In FORTRAN I/O statements (READ and WRITE), LUNs 1, 3, 4, and 5 default to the console/keyboard (*DO/*KI), LUN 2 defaults to the line printer (*PR), and LUNs 6-10 default to the disk drive.

2.4 FORTTRAN Compiler Error Messages

Two classes of diagnostic error messages may be produced during compilation of a FORTRAN program: Warnings and Fatal Errors. When a Warning is issued, compilation continues with the next item on the source line. When a Fatal Error is found, the compiler ignores the rest of the logical line, including any continuation lines. Warning messages are preceded by percent signs (%), and Fatal Errors by question marks (?). The editor line number, if any, or the physical line number is printed next. It is followed by the error code or error message.

Example:

?Line 25: Mismatched Parentheses

%Line 16: Missing Integer Variable

When either type of error occurs, the program should be changed so that it compiles without errors. No guarantee is made that a program that compiles with errors will execute sensibly.

Fatal Errors:

<u>Error Number</u>	<u>Message</u>
100	Illegal Statement Number
101	Statement Unrecognizable or Misspelled
102	Illegal Statement Completion
103	Illegal DO Nesting
104	Illegal Data Constant
105	Missing Name
106	Illegal Procedure Name
107	Invalid DATA Constant or Repeat Factor
108	Incorrect Number of DATA Constants
109	Incorrect Integer Constant
110	Invalid Statement Number
111	Not a Variable Name
112	Illegal Logical Form Operator
113	Out of Memory
114	Literal String Too Large
115	Invalid Data List Element in I/O
116	Unbalanced DO Nest
117	Identifier Too Long
118	Illegal Operator
119	Mismatched Parenthesis
120	Consecutive Operators
121	Improper Subscript Syntax
122	Illegal Integer Quantity
123	Illegal Hollerith Construction
124	Backwards DO reference

125	Illegal Statement Function Name
126	Illegal Character for Syntax
127	Statement Out of Sequence
128	Missing Integer Quantity
129	Invalid Logical Operator
130	Illegal Item Following INTEGER or REAL or LOGICAL
131	Premature End Of File on Input Device
132	Illegal Mixed Mode Operation
133	Function Call with No Parameters
134	Stack Overflow
135	Illegal Statement Following Logical IF

Warnings:

0	Duplicate Statement Label
1	Illegal DO Termination
2	Block Name = Procedure Name
3	Array Name Misuse
4	COMMON Name Usage
5	Wrong Number of Subscripts
6	Array Multiply EQUIVALENCED within a Group
7	Multiple EQUIVALENCE of COMMON
8	COMMON Base Lowered
9	Non-COMMON Variable in BLOCK DATA
10	Empty List for Unformatted WRITE
11	Non-Integer Expression
12	Operand Mode Not Compatible with Operator
13	Mixing of Operand Modes Not Allowed
14	Missing Integer Variable
15	Missing Statement Number on FORMAT
16	Zero Repeat Factor
17	Zero Format Value
18	Format Nest Too Deep
19	Statement Number Not FORMAT Associated
20	Invalid Statement Number Usage
21	No Path to this Statement
22	Missing Do Termination
23	Code Output in BLOCK DATA
24	Undefined Labels Have Occurred
25	RETURN in a Main Program
26	STATUS Error on READ
27	Invalid Operand Usage
28	Function with no Parameter
29	Hex Constant Overflow
30	Division by Zero
32	Array Name Expected
33	Illegal Argument to ENCODE/DECODE

SECTION 3

TRS-80 FORTRAN Disk Files

SEE ALSO FORTRAN-80 REFERENCE MANUAL, SECTION 8.3.

3.1 Default Disk Filenames

TRS-80 FORTRAN may access either random or sequential disk files. When a disk file is opened by a READ or WRITE statement, the file is given a default filename that depends on the LUN:

<u>LUN</u>	<u>Default Filename</u>
6	FORT06/DAT
7	FORT07/DAT
8	FORT08/DAT
9	FORT09/DAT
10	FORT10/DAT

These default filenames are assigned only when the user does not explicitly call the OPEN subroutine and specify a name for the file (see below).

3.2 CALL OPEN

To explicitly OPEN a disk file with a filename that you specify, do a "CALL OPEN." OPEN is the subroutine that opens a disk file for input/output (READING and WRITing). (See the FORTRAN-80 Reference Manual, Section 8.3.2.) The format of an OPEN call is:

```
CALL OPEN (LUN, Filename, Reclen)
```

where:

LUN = a Logical Unit Number to be associated with the file (must be an Integer constant or Integer variable with a value between 1 and 10).

Filename = an ASCII name which TRSDOS will associate with the file. The Filename should be a Hollerith or Literal constant, or a variable or array name where the variable or array contains the ASCII name. The Filename should be in the form normally required by TRSDOS,

```
filename/ext.password:drive#
```

and it should be terminated with a non-alpha

character, preferably a blank.

Reclen = The number of bytes you wish to specify (up to 256) as the record length. Reclen must be an Integer constant or Integer variable. If zero is supplied for Reclen, the record length will be 256 bytes.

The following are examples of valid OPEN calls:

```
CALL OPEN (6,'TIME/DAT.JULY:1 ',256)
```

```
CALL OPEN (7,'COUNT/NUM ',200)
```

```
CALL OPEN (1,'TESTQ/MIN:2 ',100)
```


SECTION 4

LINK-80 Linking Loader

As demonstrated in the Sample Session, compiled FORTRAN programs are loaded into memory, linked, and executed using the LINK-80 linking loader. The linking loader converts the compiled relocatable object version of your program into an absolute version that is executable. It automatically combines the required portions of the FORTRAN runtime library with your object program. The loader is also used to link one or more FORTRAN subprograms together with a main program.

A file containing the executable memory image produced by LINK-80 can be saved on disk and run at a later time.

4.1 RUNNING LINK-80

Place the diskette containing LINK-80 in disk drive 1. At TRSDOS command level, enter:

L80

This loads LINK-80, which returns an asterisk (*) to indicate command level. The loader exits back to TRSDOS if a <break> is typed after the asterisk. (The loader also exits back to TRSDOS after a -E switch or -G switch is executed. More on these switches later.)

4.2 LINK-80 COMMAND FORMAT

A command to LINK-80 is made up of the filename(s) of the file(s) to be loaded. For example, to load the compiled program TEMP/REL, put the diskette containing TEMP/REL into drive 0 and (at LINK-80 command level) enter:

TEMP

(It is not necessary to type the default extension /REL.) This loads the program but does not run it. To run TEMP, enter

-G

This is the "go" or execute switch. LINK-80 prints two numbers and a BEGIN EXECUTION message. LINK-80 always returns to TRSDOS after a -G switch has been executed.

As you probably have guessed, it is not necessary to perform the above operations with separate commands. It is possible to type one command line that runs LINK-80, loads TEMP/REL and executes it. Place the FORTRAN 2 diskette in drive 1 and the diskette which contains TEMP/REL into drive 0, and enter:

```
L80 TEMP/REL-G
```

4.3 MORE COMMANDS AND SWITCHES

LINK-80 provides other capabilities besides loading and executing programs, such as looking at output without saving the program or resetting the loader so that you can correct a mistake. Switches are used to inform LINK-80 that you wish to perform special tasks.

Here is an example that loads and saves a program called TEST/REL.

```
>L80
*TEST,TEST-N-E
```

The first part of the command (TEST) loads the program called TEST/REL. The next part (TEST-N) saves a copy of the loaded program on disk in a file called TEST/CMD. The last part (-E) causes LINK-80 to exit back to TRSDOS.

4.3.1 THE -N SWITCH

Take note of the -N switch. This switch saves a disk file of the executable memory image. The default extension for the saved file is /CMD, and this file is called a "command file." Once saved on disk, you need only type the filename at TRSDOS command level to run the program. The -N switch must immediately follow the filename of each file you wish to save, and it does not take effect until a -E or -G switch is done.

The following example links several object files, saves the main program image and executes the program TAXES/REL.

```
>L80
*SUB1,SUB2,TAXES-N,TAXES-G
```

Two FORTRAN subprograms (SUB1/REL and SUB2/REL) and a main program (TAXES/REL) are linked and loaded. The program is executed and the command file

TAXES/CMD is saved on disk.

4.3.2 THE -R SWITCH

Another handy switch is -R. It returns LINK-80 to its initial state by "unloading" whatever you've loaded. Use it to reset the loader if you've made a typing mistake or loaded the wrong program. The -R switch takes effect as soon as LINK-80 sees it, so if you enter it at any time while LINK-80 is running, the loader will reset. For example:

```
>L80
*INVEN1
*-R          (oops--meant to load INVEN2)
*INVEN2
*           (now only INVEN2 is loaded)
```

4.3.3 SPECIAL SWITCHES

For typical FORTRAN-80 operation, only the above switches will be needed. Some users may find that their applications require more specialized capabilities. For this reason, the following switches are also provided with LINK-80.

In the examples above, all programs have been loaded at the default origins for TRSDOS. In special cases, the user may wish to specify the origins of the programs and data that are loaded. LINK-80 provides special switches to do this.

-P & -D -P and -D allow the origin(s) to be set for the next program loaded. -P and -D take effect when seen (not deferred), and they have no effect on programs already loaded. The form is -P:<address> or -D:<address>, where <address> is the desired origin in the current typeout radix. (Default radix is hexadecimal. -O sets radix to octal; -H to hex.) LINK-80 does a default -P:<link origin> (i.e., 5200).

If no -D is given, data areas are loaded before program areas for each module. If a -D is given, all Data and Common areas are loaded starting at the data origin and the program area at the program origin. Example:

```
*-P:200
*MYPROG
Data      200      300
*-R
*-P:200-D:400
*MYPROG
Data      400      480
Program 200      280
```

NOTE

If -D is given and the data origin is less than the program area, the user must be sure there is enough room to keep the program from being destroyed.

- U List the origin and end of the program and data area and all undefined globals as soon as the current command line has been interpreted. The program information is only printed if a -D has been done. Otherwise, the program is stored in the data area.
- M List the origin and end of the program and data area, all defined globals and their values, and all undefined globals followed by an asterisk. The program information is only printed if a -D has been done. Otherwise, the program is stored in the data area.

4.4 SYSTEM LIBRARY SEARCHES

Whenever LINK-80 saves or executes a FORTRAN program (-N or -G), it automatically searches the FORTRAN library and links the appropriate routines. There is also a switch (-S) which forces a search of the system library. You probably will never use -S with TRS-80 FORTRAN, unless you have a single-drive system. With a single-drive system it is necessary to load the program and search the library in two separate steps, in which case the command:

```
*FORLIB-S
```

is required to force a search of the FORTRAN library. See Appendix A if you are using TRS-80 FORTRAN with a single-drive system.

4.5 LINK-80 ERROR MESSAGES

LINK-80 has the following error messages:

?No Start Address	A -G switch was issued, but no main program had been loaded.
?Loading Error	The last file given for input was not a properly formatted LINK-80 object file.
?Out of Memory	Not enough memory to load program.
?Command Error	Unrecognizable LINK-80 command.
?<file> Not Found	<file>, as given in the command string, did not exist.
%2nd COMMON Larger /XXXXXX/	The first definition of COMMON block /XXXXXX/ was not the largest definition. Reorder module loading sequence or change COMMON block definitions.
%Mult. Def. Global YYYYYY	More than one definition for the global (internal) symbol YYYYYY was encountered during the loading process.
%Overlaying Program Area	,Start = xxxx
Data	,Public = <symbol name>(xxxx)
	,External = <symbol name>(xxxx)
	A -D or -P will cause already loaded data to be destroyed.
?Intersecting Program Area	
Data	The program and data area intersect and an address or external chain entry is in this intersection. The final value cannot be converted to a current value since it is in the area intersection.

Origin Above Loader Memory, Move Anyway (Y or N)?
 Below

While attempting to execute a -E or -G, LINK-80 discovers that either the data or program area has an origin which lies above (or below) the addresses that LINK-80 "recognizes" as the boundaries of working memory. If you answer "Y", LINK-80 will go ahead and load there, even though some other portion of the system (probably TRSDOS) will be destroyed. If you answer "N", LINK-80 will exit to TRSDOS. In either case, if a -N was given first, the CMD file will already have been saved on disk.

?Can't Save Object File

A disk error occurred when the file was being saved. This is most often caused by insufficient disk space when LINK-80 tried to save the file.

SECTION 5

EXECUTING FORTRAN PROGRAMS

You may execute a FORTRAN program in one of two ways. The first is to use the -G switch in the loader command string as described in Section 4.2. The second is simply to type the name of an executable program file as saved by using the -N switch in the loader command string.

In either case, your program should execute and your output should appear on the screen. However, you may get a runtime error message. If you do, look it up in the following list, and return to EDIT-80 to debug your source file so that no error is produced at runtime.

5.1 FORTRAN Runtime Error Messages

During execution of a FORTRAN program one or more of the following errors could occur. Fatal errors cause execution to cease. Execution continues after a warning error. However, execution will cease after 20 warnings. Runtime errors are surrounded by asterisks as follows:

****FW****

Warning Errors:

IB	Input Buffer Limit Exceeded
TL	Too Many Left Parentheses in FORMAT
OB	Output Buffer Limit Exceeded
DE	Decimal Exponent Overflow (Number in input stream had an exponent larger than 99)
IS	Integer Size Too Large
BE	Binary Exponent Overflow
IN	Input Record Too Long
OV	Arithmetic Overflow
CN	Conversion Overflow on REAL to INTEGER Conversion
SN	Argument to SIN Too Large
A2	Both Arguments of ATAN2 are 0
BI	Buffer Size Exceeded During Binary I/O
RC	Negative Repeat Count in FORMAT
FW	FORMAT Field Width is Too Small
EX	Illegal Exponentiation
GL	Computed GOTO Number Too Large
GS	Computed GOTO Number Too Small

Fatal Errors:

ID	Illegal FORMAT Descriptor
F0	FORMAT Field Width is Zero
MP	Missing Period in FORMAT
IT	I/O Transmission Error
ML	Missing Left Parenthesis in FORMAT
DZ	Division by Zero, REAL or INTEGER
LG	Illegal Argument to LOG Function (Negative or Zero)
IO	Illegal I/O Operation
SQ	Illegal Argument to SQRT Function (Negative)
DT	Data Type Does Not Agree With FORMAT Specification
EF	EOF Encountered on READ
IR	I FIELD REAL
DO	Illegal Increment or Limit in DO Loop
FN	File Not Found on OPEN
DF	Disk Full Encountered on WRITE
UN	Logical Unit Number (LUN) Too Large
OM	Out of Memory

NOTE

It is possible, in rare cases, to get a FORTRAN-80 internal error, as designated by the error code "??". This indicates an internal malfunction of the runtime. If you get the "??" error code, contact Microsoft and report the conditions under which the message appeared.

APPENDIX A

Using TRS-80 FORTRAN
with a Single-Drive System

The sample session given in Section 1.2 of this manual assumes the user has two or more disk drives. The following steps illustrate one method of using TRS-80 FORTRAN on a single-drive system to create, compile and execute TEMP/FOR:

1. Create a blank work diskette using the BACKUP utility in TRSDOS.
2. Place the diskette labelled FORTRAN 2 in the drive and type:

EDIT

When the editor responds with:

FILE:

remove the diskette and insert your work diskette.
Then type:

TEMP/FOR <break>

3. Enter the command

I

for automatic line number generation. Enter the FORTRAN program (as shown in Figure 1), and type <break> to return to EDIT-80 command level. To exit the editor, enter the command:

E

The FORTRAN program TEMP/FOR has been written to your work diskette.

4. Insert the diskette labelled FORTRAN 1 and type:

F80

The compiler will load into memory and prompt with "*". When the prompt appears, insert the work diskette again and type:

=TEMP

to do a syntax check, or type:

TEMP,TEMP=TEMP

to create listing and relocatable files.

5. To load and execute the program, insert the diskette labelled FORTRAN 2 and type:

L80

When the "*" prompt appears, insert the work diskette and type:

TEMP

This loads the program. The loader will display a list of undefined references (library routines) and another prompt. Insert FORTRAN 2 again and type:

FORLIB-S

to search the library and load the necessary routines. When the prompt appears again, insert the work diskette and type:

TEMP-N-E

This will save TEMP/CMD on the work diskette. The program may now be executed by simply typing:

TEMP

APPENDIX B

Format of Link Compatible Object Files

NOTE

This appendix is reference material for users who wish to know the load format of LINK-80 relocatable object files. This information is provided ONLY for users who have specialized skills and the specific need to access these files. Most users will NOT require this material, as it is NOT necessary to the operation of LINK-80.

LINK-compatible object files consist of a bit stream. Individual fields within the bit stream are not aligned on byte boundaries, except as noted below. Use of a bit stream for relocatable object files keeps the size of object files to a minimum, thereby decreasing the number of disk reads/writes.

There are two basic types of load items: Absolute and Relocatable. The first bit of an item indicates one of these two types. If the first bit is a 0, the following 8 bits are loaded as an absolute byte. If the first bit is a 1, the next 2 bits are used to indicate one of four types of relocatable items:

- 00 Special LINK item (see below).
- 01 Program Relative. Load the following 16 bits after adding the current Program base.
- 10 Data Relative. Load the following 16 bits after adding the current Data base.
- 11 Common Relative. Load the following 16 bits after adding the current Common base.

Special LINK items consist of the bit stream 100 followed by:

a four-bit control field

an optional A field consisting of a two-bit address type that is the same as the two-bit field above except 00 specifies absolute address

an optional B field consisting of 3 bits that give a symbol length and up to 8 bits for each character of the symbol

A general representation of a special LINK item is:

1	00	xxxx	yy	nn	zzz + characters of symbol name
		-----		-----	
		A field		B field	

xxxx	Four-bit control field (0-15 below)
yy	Two-bit address type field
nn	Sixteen-bit value
zzz	Three-bit symbol length field

The following special types have a B-field only:

0	Entry symbol (name for search)
1	Select COMMON block
2	Program name
3	Request library search
4	Reserved for future expansion

The following special LINK items have both an A field and a B field:

5	Define COMMON size
6	Chain external (A is head of address chain, B is name of external symbol)
7	Define entry point (A is address, B is name)
8	Reserved for future expansion

The following special LINK items have an A field only:

- 9 External + offset. The A value will be added to the two bytes starting at the current location counter immediately before execution.
- 10 Define size of Data area (A is size)
- 11 Set loading location counter to A
- 12 Chain address. A is head of chain, replace all entries in chain with current location counter.
 The last entry in the chain has an address field of absolute zero.
- 13 Define program size (A is size)
- 14 End program (forces to byte boundary)

The following special Link item has neither an A nor a B field:

- 15 End file

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APPENDIX C

FORTRAN Programs in ROM

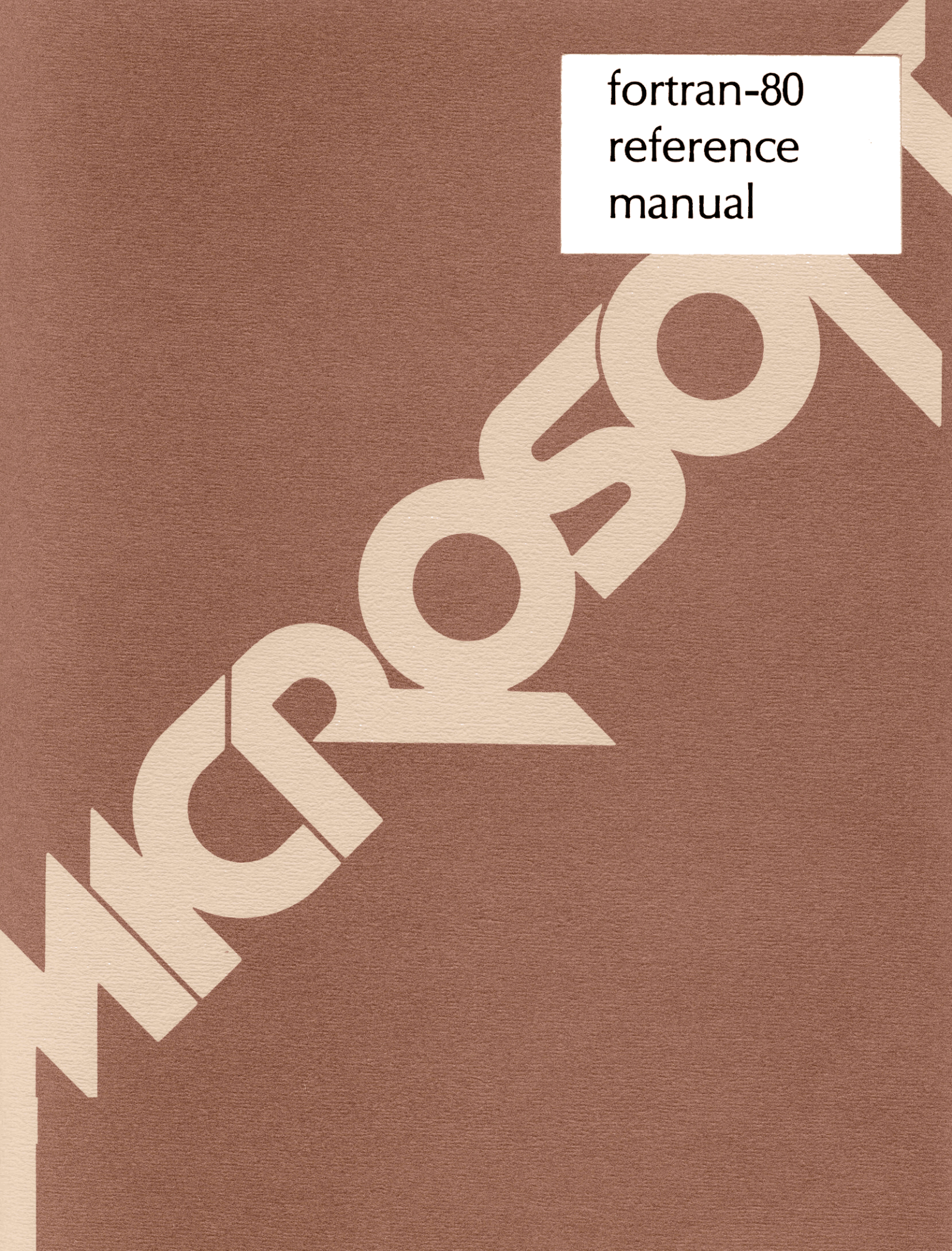
If a FORTRAN program is intended for ROM, the programmer should be aware of the following ramifications:

1. DATA statements should not be used to initialize RAM. Such initialization is done by the loader, and will therefore not be present at execution. Variables and arrays may be initialized during execution via assignment statements, or by READING into them.
2. FORMATS should not be read into during execution.
3. If the standard library I/O routines are used, DISK files should not be OPENED on any LUNs other than 6, 7, 8, 9, 10. If other LUNs are needed for Disk I/O, \$LUNTB should be reassembled with the appropriate addresses pointing to the Disk driver routine.

LUNTB\$ must be assembled with the MACRO-80 Assembler, which is not included in the TRS-80 FORTRAN package. MACRO-80 is supplied with the TRS-80 Assembly Language Development System, available from Microsoft Consumer Products.

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Microsoft FORTRAN-80
for the Radio Shack
TRS-80 Model I Computer

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TRS-80 Model I Computer

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Addendum to: FORTRAN-80 Reference Manual
For TRS-80 Model I

Add to Section 8.2, Unformatted READ/WRITE:

Unformatted I/O is possible to disk ONLY. Unformatted I/O
is not possible to a CRT or printer.

Add to Section 8.7.9, FORMAT Carriage Control:

FORTRAN-80 for TRS-80 Model I does NOT allow line feeds to
be suppressed from within FORTRAN programs. Thus, the
Format Control character "+" is not applicable to TRS-80
FORTRAN.

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MICROSOFT FORTRAN-80
Reference Manual

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SECTION 1

INTRODUCTION

FORTRAN is a universal, problem oriented programming language designed to simplify the preparation and check-out of computer programs. The name of the language - FORTRAN - is an acronym for FORMula TRANslator.

The syntactical rules for using the language are rigorous and require the programmer to define fully the characteristics of a problem in a series of precise statements. These statements, called the source program, are translated by a system program called the FORTRAN processor into an object program in the machine language of the computer on which the program is to be executed.

This manual defines the FORTRAN source language for the 8080 and Z-80 microcomputers. This language includes the American National Standard FORTRAN language as described in ANSI document X3.9-1966, approved on March 7, 1966, plus a number of language extensions and some restrictions. These language extensions and restrictions are described in the text of this document and are listed in Appendix A.

NOTE

This FORTRAN differs from the Standard in that it does not include the COMPLEX data type.

Examples are included throughout the manual to illustrate the construction and use of the language elements. The programmer should be familiar with all aspects of the language to take full advantage of its capabilities.

Section 2 describes the form and components of an FORTRAN-80 source program. Sections 3 and 4 define data types and their expressional relationships. Sections 5 through 9 describe the proper construction and usage of the various statement classes.

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SECTION 2

FORTRAN PROGRAM FORM

FORTRAN-80 source programs consist of one program unit called the Main program and any number of program units called subprograms. A discussion of subprogram types and methods of writing and using them is in Section 9 of this manual.

Programs and program units are constructed of an ordered set of statements which precisely describe procedures for solving problems and which also define information to be used by the FORTRAN processor during compilation of the object program. Each statement is written using the FORTRAN character set and following a prescribed line format.

2.1 FORTRAN CHARACTER SET

To simplify reference and explanation, the FORTRAN character set is divided into four subsets and a name is given to each.

2.1.1 LETTERS

A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R,S,T,U,
V,W,X,Y,Z,\$

No distinction is made between upper and lower case letters. However, for clarity and legibility, exclusive use of upper case letters is recommended.

2.1.2 DIGITS

0,1,2,3,4,5,6,7,8,9

Strings of digits representing numeric quantities are normally interpreted as decimal numbers. However, in certain statements, the interpretation is in the Hexadecimal number system in which case the letters A, B, C, D, E, F may also be used as Hexadecimal digits. Hexadecimal usage is defined in the descriptions of statements in which such notation is allowed.

2.1.3 ALPHANUMERICS

A sub-set of characters made up of all letters and all digits.

2.1.4 SPECIAL CHARACTERS

	Blank
=	Equality Sign
+	Plus Sign
-	Minus Sign
*	Asterisk
/	Slash
(Left Parenthesis
)	Right Parenthesis
,	Comma
.	Decimal Point

NOTES:

1. FORTRAN program lines consist of 80 character positions or columns, numbered 1 through 80. They are divided into four fields.
2. The following special characters are classified as Arithmetic Operators and are significant in the unambiguous statement of arithmetic expressions.

+	Addition or Positive Value
-	Subtraction or Negative Value
*	Multiplication
/	Division
3. The other special characters have specific application in the syntactical expression of the FORTRAN language and in the construction of FORTRAN statements.
4. Any printable character may appear in a Hollerith or Literal field.

2.2 FORTRAN LINE FORMAT

A FORTRAN program line consists of up to 80 columns, divided into four fields:

1. Statement Label (or Number) field- Columns 1 through 5 (See definition of statement labels).
2. Continuation character field- Column 6
3. Statement field- Columns 7 through 72
4. Indentification field- Columns 73 through 80

The identification field is available for any purpose the FORTRAN programmer may desire and is ignored by the FORTRAN processor.

The lines of a FORTRAN statement are placed in Columns 1 through 72 formatted according to line types. The four line types, their definitions, and column formats are:

1. Initial Line -- the first or only line of each statement.
 1. Columns 1-5 may contain a statement label to identify the statement.
 2. Column 6 must be blank.
 3. Columns 7-72 contain all or part of the statement.
 4. An initial line may begin anywhere within the statement field.

Example:

```
C THE STATEMENT BELOW CONSISTS
C   OF AN INITIAL LINE
C
      A= .5*SQRT(3-2.*C)
```

2. Continuation Line -- used when additional lines of coding are required to complete a statement originating with an initial line.
 1. Columns 1-5 are ignored, unless Column 1 contains a C.
 2. If Column 1 contains a C, it is a comment line.
 3. Column 6 must contain a character other than zero or blank.
 4. Columns 7-72 contain the continuation of the statement.
 5. There may be as many continuation lines as needed to complete the statement.

Example:

```
C THE STATEMENTS BELOW ARE AN INITIAL LINE
C      AND 2 CONTINUATION LINES
C
63 BETA(1,2) =
   1      A6BAR**7-(BETA(2,2)-A5BAR*50
   2      +SQRT (BETA(2,1)))
```

3. Comment line -- used for source program annotation at the convenience of the programmer.
 1. Column 1 contains the letter C.
 2. Columns 2 - 72 are used in any desired format to express the comment or they may be left blank.
 3. A comment line may be followed only by an initial line, an END line, or another comment line.
 4. Comment lines have no effect on the object program and are ignored by the FORTRAN processor except for display purposes in the listing of the program.

Example:

```
C      COMMENT LINES ARE INDICATED BY THE
C      CHARACTER C IN COLUMN 1.
C THESE ARE COMMENT LINES
```

4. END line -- the last line of a program unit.
 1. Columns 1-5 may contain a statement label.
 2. Column 6 must be blank.
 3. Columns 7-72 contain the END statement.
 4. Each FORTRAN program unit must have an END line as its last line to inform the Processor that it is at the physical end of the program unit.
 5. An END line may follow any other type line.

A statement label may be placed in columns 1-5 of a FORTRAN statement initial line and is used for

reference purposes in other statements.

The following considerations govern the use of statement labels:

1. The label is an integer from 1 to 99999.
2. The numeric value of the label, leading zeros and blanks are not significant.
3. A label must be unique within a program unit.
4. A label on a continuation line is ignored by the FORTRAN Processor.

Example:

```
C  EXAMPLES OF STATEMENT LABELS
C
   1
  101
99999
  763
```

2.3 STATEMENTS

Individual statements deal with specific aspects of a procedure described in a program unit and are classified as either executable or non-executable.

Executable statements specify actions and cause the FORTRAN Processor to generate object program instructions. There are three types of executable statements:

1. Replacement statements.
2. Control statements.
3. Input/Output statements.

Non-executable statements describe to the processor the nature and arrangement of data and provide information about input/output formats and data initialization to the object program during program loading and execution. There are five types of non-executable statements:

1. Specification statements.
2. DATA Initialization statements.
3. FORMAT statements.
4. FUNCTION defining statements.
5. Subprogram statements.

The proper usage and construction of the various types of statements are described in Sections 5 through 9.

2.4 INCLUDE STATEMENT

The INCLUDE statement causes the compiler to bring an outside FORTRAN source program into the current program. The format of the statement is

INCLUDE<filename>

Use of INCLUDE eliminates the need to repeat an often-used sequence of statements in the current source file.

SECTION 3

DATA REPRESENTATION / STORAGE FORMAT

The FORTRAN Language prescribes a definitive method for identifying data used in FORTRAN programs by name and type.

3.1 DATA NAMES AND TYPES3.1.1 NAMES

1. Constant - An explicitly stated datum.
2. Variable - A symbolically identified datum.
3. Array - An ordered set of data in 1, 2 or 3 dimensions.
4. Array Element - One member of the set of data of an array.

3.1.2 TYPES

1. Integer -- Precise representation of integral numbers (positive, negative or zero) having precision to 5 digits in the range -32768 to +32767 inclusive (-2^{15} to $2^{15}-1$).
2. Real -- Approximations of real numbers (positive, negative or zero) represented in computer storage in 4-byte, floating-point form. Real data are precise to 7+ significant digits and their magnitude may lie between the approximate limits of 10^{-38} and 10^{38} (2^{-127} and 2^{127}).
3. Double Precision -- Approximations of real numbers (positive, negative or zero) represented in computer storage in 8-byte, floating-point form. Double Precision data are precise to 16+ significant digits in the same magnitude range as real data.
4. Logical -- One byte representations of the truth values "TRUE" or "FALSE" with "FALSE" defined to have an internal representation of zero. The constant .TRUE. has the value -1, however any non-zero value will be treated as .TRUE. in a Logical IF statement. In addition, Logical types may be used as one byte signed integers in the range -128 to +127, inclusive.

5. Hollerith -- A string of any number of characters from the computer's character set. All characters including blanks are significant. Hollerith data require one byte for storage of each character in the string.
6. Extended Integer -- INTEGER*4 is an extended precision representation using 32-bit two's complement (four 8-bit bytes) for 9+ significant digits in the range -2147483648 to +2147483647 inclusive (-2^{31} to $2^{31}-1$).

Integer*4 variables cannot be used as Logical Unit Numbers, array indices, implied DO loop indices, or as the control variable in computed or assigned GOTO statements.

3.2 CONSTANTS

FORTRAN constants are identified explicitly by stating their actual value. The plus (+) character need not precede positive valued constants.

Formats for writing constants are shown in Table 3-1.

Table 3-1. CONSTANT FORMATS

<u>TYPE</u>	<u>FORMATS AND RULES OF USE</u>	<u>EXAMPLES</u>
INTEGER	1. 1 to 5 decimal digits interpreted as a decimal number.	-763 1 +00672
	2. A preceding plus (+) or minus (-) sign is optional.	-32768 +32767
	3. No decimal point (.) or comma (,) is allowed but spaces are permitted in the source program.	- 32 767
	4. Value range: -32768 through +32767 (.i.e., -2^{15} through $2^{15}-1$).	
REAL	1. A decimal number with precision to 7 digits and represented in one of the following forms: a. + or -.f + or -i.f b. + or -i.E+ or -e + or -.fE+ or -e + or -i.fE+ or -e where i, f, and e are each strings representing integer, fraction, and exponent respectively.	345. -.345678 +345.678 +.3E3 -73E4
	2. Plus (+) and minus (-) characters are optional. 3. In the form shown in 1 b above, if r represents any of the forms preceding E+ or -e (i.e., rE+ or -e), the value of the constant is interpreted as r times 10^e , where $-38 \leq e \leq 38$.	

<u>TYPE</u>	<u>FORMATS AND RULES OF USE</u>	<u>EXAMPLES</u>
	4. If the constant preceding E+ or -e contains more significant digits than the precision for real data allows, truncation occurs, and only the most significant digits in the range will be represented.	
DOUBLE	A decimal number with	+345.678
PRECISION	precision to 16 digits. All formats and rules are identical to those for REAL constants, except D is used in place of E. Note that a real constant is assumed single precision unless it contains a "D" exponent.	+ .3D3 -73D4
LOGICAL	.TRUE. generates a non-zero byte (hexadecimal FF) and .FALSE. generates a byte in which all bits are 0. If logical values are used as one-byte integers, the rules for use are the same as for type INTEGER, except that the range allowed is -128 to +127, inclusive.	.TRUE. .FALSE.

<u>TYPE</u>	<u>FORMATS AND RULES OF USE</u>	<u>EXAMPLES</u>
LITERAL	<p>In the literal form, any number of characters may be enclosed by single quotation marks. The form is as follows:</p> <p style="text-align: center;">'X₁X₂X₃...X_n'</p> <p>where each X_i is any character other than '. Two quotation marks in succession may be used to represent the quotation mark character within the string, i.e., if X₂ is to be the quotation mark character, the string appears as the following:</p> <p style="text-align: center;">'X₁' 'X₃...X_n'</p>	
HEXADECIMAL	<p>1. The letter Z or X followed by a single quote, up to 4 hexadecimal digits (0-9 and A-F) and a single quote is recognized as a hexadecimal value.</p> <p>2. A hexadecimal constant is right justified in its storage value.</p>	<p>Z'12'</p> <p>X'AB1F'</p> <p>Z'FFFF'</p> <p>X'1F'</p>
INTEGER*4	<p>1. One to ten decimal digits interpreted as a decimal number.</p> <p>2. A preceding plus or minus sign is optional.</p> <p>3. No decimal point or comma is allowed, but spaces are permitted in the source program.</p> <p>4. Value range: -2147483648 through 2147483647 (i.e., -2**31 through 2**31-1).</p>	<p>1234567890</p> <p>0</p> <p>-2147483647</p> <p>- 2 147 483 647</p>

3.3 VARIABLES

Variable data are identified in FORTRAN statements by symbolic names. The names are unique strings of from 1 to 6 alphanumeric characters of which the first is a letter.

NOTE

System variable names and runtime subprogram names are distinguished from other variable names in that they begin with the dollar sign character (\$). It is therefore strongly recommended that in order to avoid conflicts, symbolic names in FORTRAN source programs begin with some letter other than "\$".

Examples:

I5, TBAR, B23, ARRAY, XFM79, MAX, AL\$C

Variable data are classified into four types: INTEGER, REAL, DOUBLE PRECISION and LOGICAL. The specification of type is accomplished in one of the following ways:

1. Implicit typing in which the first letter of the symbolic name specifies Integer or Real type. Unless explicitly typed (2., below), symbolic names beginning with I, J, K, L, M or N represent Integer variables, and symbolic names beginning with letters other than I, J, K, L, M or N represent Real variables.

Integer Variables

ITEM
J1
MODE
K123
N2

Real Variables

BETA
H2
ZAP
AMAT
XID

2. Variables may be typed explicitly. That is, they may be given a particular type without reference to the first letters of their names. Variables may be explicitly typed as INTEGER, REAL, DOUBLE PRECISION or LOGICAL. The specific statements used in explicitly typing data are described in Section 6.

Variable data receive their numeric value assignments during program execution or, initially, in a DATA statement (Section 6).

Hollerith or Literal data may be assigned to any type variable. Sub-paragraph 3.6 contains a discussion of Hollerith data storage.

3.4 ARRAYS AND ARRAY ELEMENTS

An array is an ordered set of data characterized by the property of dimension. An array may have 1, 2 or 3 dimensions and is identified and typed by a symbolic name in the same manner as a variable except that an array name must be so declared by an "array declarator." Complete discussions of the array declarators appear in Section 6 of this manual. An array declarator also indicates the dimensionality and size of the array. An array element is one member of the data set that makes up an array. Reference to an array element in a FORTRAN statement is made by appending a subscript to the array name. The term array element is synonymous with the term subscripted variable used in some FORTRAN texts and reference manuals.

An initial value may be assigned to any array element by a DATA statement or its value may be derived and defined during program execution.

3.5 SUBSCRIPTS

A subscript follows an array name to uniquely identify an array element. In use, a subscript in a FORTRAN statement takes on the same representational meaning as a subscript in familiar algebraic notation.

Rules that govern the use of subscripts are as follows:

1. A subscript contains 1, 2 or 3 subscript expressions (see 4 below) enclosed in parentheses.
2. If there are two or three subscript expressions within the parentheses, they must be separated by commas.
3. The number of subscript expressions must be the same as the specified dimensionality of the Array Declarator except in EQUIVALENCE statements (Section 6).
4. A subscript expression is written in one of the following forms:

K	C*V	V-K
V	C*V+K	C*V-K
V+K		

where C and K are integer constants and V is an integer variable name (see Section 4 for a discussion of expression evaluation).

5. Subscripts themselves may not be subscripted.
Examples:

X(2*J-3,7) A(I,J,K) I(20) C(L-2) Y(I)

3.6 DATA STORAGE ALLOCATION

Allocation of storage for FORTRAN data is made in numbers of storage units. A storage unit is the memory space required to store one real data value (4 bytes).

Table 3-2 defines the word formats of the three data types.

Hexadecimal data may be associated (via a DATA statement) with any type data. Its storage allocation is the same as the associated datum.

Hollerith or literal data may be associated with any data type by use of DATA initialization statements (Section 6).

Up to eight Hollerith characters may be associated with Double Precision type storage, up to four with Real or Integer*4, up to two with Integer*2, and one with Logical type storage.

TABLE 3-2. STORAGE ALLOCATION BY DATA TYPES

<u>TYPE</u>	<u>ALLOCATION</u>						
INTEGER	2 bytes/ 1/2 storage unit <table><tr><td>S</td><td>Binary Value</td></tr></table> <p>Negative numbers are the two's complement of positive representations. The storage order is reversed. The least significant byte is followed by the most significant byte.</p>	S	Binary Value				
S	Binary Value						
LOGICAL	1 byte/ 1/4 storage unit <table><tr><td>Zero</td><td>(false) or</td><td>non-zero</td><td>(true)</td></tr></table> <p>A non-zero valued byte indicates true (the logical constant <code>.TRUE.</code> is represented by the hexadecimal value <code>FF</code>). A zero valued byte indicates false.</p> <p>When used as an arithmetic value, a Logical datum is treated as an Integer in the range -128 to +127.</p>	Zero	(false) or	non-zero	(true)		
Zero	(false) or	non-zero	(true)				
REAL	4 bytes/ 1 storage unit <table><tr><td>Characteristic</td><td>S</td><td>Mantissa (hi)</td></tr><tr><td>Mantissa (mid)</td><td></td><td>Mantissa (low)</td></tr></table> <p>The first byte is the characteristic expressed in excess 200 (octal) notation; i.e., a value of 200 (octal) corresponds to a binary exponent of 0. Values less than 200 (octal) correspond to negative exponents, and values greater than 200 correspond to positive exponents. By definition, if the characteristic is zero, the entire number is zero.</p> <p>The next three bytes constitute the mantissa. The mantissa is always normalized such that the high order bit is one, eliminating the need to actually save that bit. The high bit is used instead to indicate the sign of the number. A one indicates a negative number, and zero indicates a positive number. The mantissa is assumed to be a binary fraction whose binary point is to the left of the mantissa. The format of the mantissa is "signed magnitude." The bytes are stored in</p>	Characteristic	S	Mantissa (hi)	Mantissa (mid)		Mantissa (low)
Characteristic	S	Mantissa (hi)					
Mantissa (mid)		Mantissa (low)					

reverse order: mantissa low order, followed by mid order, high order, and characteristic.

DOUBLE
PRECISION

8 bytes/ 2 storage units

The internal form of Double Precision data is identical with that of Real data except Double Precision uses 4 extra bytes for the mantissa.

INTEGER*4

4 bytes/ 1 storage unit

Negative numbers are represented in two's complement form. The bytes are stored in reverse order, least significant to most significant.

TABLE 3-3. EQUIVALENT DATA TYPES AND SIZES

<u>Equivalent Representations</u>	<u>Size in Bytes</u>
BYTE	1
INTEGER*1	1
LOGICAL	1
INTEGER	2
INTEGER*2	2
LOGICAL*2	2
INTEGER*4	4
LOGICAL*4	4
REAL	4
REAL*4	4
DOUBLE PRECISION	8
REAL*8	8

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SECTION 4

FORTRAN EXPRESSIONS

A FORTRAN expression is composed of a single operand or a string of operands connected by operators. Two expression types --Arithmetic and Logical-- are provided by FORTRAN. The operands, operators and rules of use for both types are described in the following paragraphs.

4.1 ARITHMETIC EXPRESSIONS

The following rules define all permissible arithmetic expression forms:

1. A constant, variable name, array element reference or FUNCTION reference (Section 9) standing alone is an expression.

Examples:

S(I) JOBNO 217 17.26 SQRT(A+B)

2. If E is an expression whose first character is not an operator, then +E and -E are called signed expressions.

Examples:

-S +JOBNO -217 +17.26 -SQRT(A+B)

3. If E is an expression, then (E) means the quantity resulting when E is evaluated.

Examples:

(-A) -(JOBNO) -(X+1) (A-SQRT(A+B))

4. If E is an unsigned expression and F is any expression, then: F+E, F-E, F*E, F/E and F**E are all expressions.

Examples:

-(B(I,J)+SQRT(A+B(K,L)))
1.7E-2**(X+5.0)
-(B(I+3,3*J+5)+A)

5. An evaluated expression may be Integer, Extended Integer, Real, Double Precision, or Logical. The type is determined by the data types of the elements of the expression. If

the elements of the expression are not all of the same type, the type of the expression is determined by the element having the highest type. The type hierarchy (highest to lowest) is as follows: DOUBLE PRECISION, REAL, INTEGER*4, INTEGER, LOGICAL.

6. Expressions may contain nested parenthesized elements as in the following:

$$A*(Z-((Y+X)/T))**J$$

where $Y+X$ is the innermost element, $(Y+X)/T$ is the next innermost, $Z-((Y+X)/T)$ the next. In such expressions, care should be taken to see that the number of left parentheses and the number of right parentheses are equal.

4.2 EXPRESSION EVALUATION

Arithmetic expressions are evaluated according to the following rules:

1. Parenthesized expression elements are evaluated first. If parenthesized elements are nested, the innermost elements are evaluated, then the next innermost until the entire expression has been evaluated.
2. Within parentheses and/or wherever parentheses do not govern the order of evaluation, the hierarchy of operations in order of precedence is as follows:
 - a. FUNCTION evaluation
 - b. Exponentiation
 - c. Multiplication and Division
 - d. Addition and Subtraction

Example:

The expression

$$A*(Z-((Y+R)/T))**J+VAL$$

is evaluated in the following sequence:

```
e1 = Y+R
e2 = (e1)/T
e3 = Z-e2
e4 = e3**J
e5 = A*e4
e6 = e5+VAL
```

3. The expression $X^{**}Y^{**}Z$ is not allowed. It should be written as follows:

$(X^{**}Y)^{**}Z$ or $X^{**}(Y^{**}Z)$

4. Use of an array element reference requires the evaluation of its subscript. Subscript expressions are evaluated under the same rules as other expressions.

4.3 LOGICAL EXPRESSIONS

A Logical Expression may be any of the following:

1. A single Logical Constant (i.e., `.TRUE.` or `.FALSE.`), a Logical variable, Logical Array Element or Logical FUNCTION reference (see FUNCTION, Section 9).
2. Two arithmetic expressions separated by a relational operator (i.e., a relational expression).
3. Logical operators acting upon logical constants, logical variables, logical array elements, logical FUNCTIONS, relational expressions or other logical expressions.

The value of a logical expression is always either `.TRUE.` or `.FALSE.`

4.3.1 RELATIONAL EXPRESSIONS

The general form of a relational expression is as follows:

e1 r e2

where e1 and e2 are arithmetic expressions and r is a relational operator. The six relational operators are as follows:

.LT.	Less Than
.LE.	Less than or equal to
.EQ.	Equal to
.NE.	Not equal to
.GT.	Greater than
.GE.	Greater than or equal to

The value of the relational expression is `.TRUE.` if the condition defined by the operator is met. Otherwise, the value is `.FALSE.`

Examples:

A.EQ.B
(A**J).GT.(ZAP*(RHO*TAU-ALPH))

4.3.2 LOGICAL OPERATORS

Table 4-1 lists the logical operations. U and V denote logical expressions.

Table 4-1. Logical Operations

.NOT.U	The value of this expression is the logical complement of U (i.e., 1 bits become 0 and 0 bits become 1).
U.AND.V	The value of this expression is the logical product of U and V (i.e., there is a 1 bit in the result only where the corresponding bits in both U and V are 1.
U.OR.V	The value of this expression is the logical sum of U and V (i.e., there is a 1 in the result if the corresponding bit in U or V is 1 or if the corresponding bits in both U and V are 1.
U.XOR.V	The value of this expression is the exclusive OR of U and V (i.e., there is a one in the result if the corresponding bits in U and V are 1 and 0 or 0 and 1 respectively.

Examples:

If U = 01101100 and V = 11001001 , then

```
.NOT.U   = 10010011
U.AND.V  = 01001000
U.OR.V   = 11101101
U.XOR.V  = 10100101
```

The following are additional considerations for construction of Logical expressions:

1. Any Logical expression may be enclosed in parentheses. However, a Logical expression to which the .NOT. operator is applied must be enclosed in parentheses if it contains two or more elements.
2. In the hierarchy of operations, parentheses may be used to specify the ordering of the expression evaluation. Within parentheses, and where parentheses do not dictate evaluation order, the order is understood to be as follows:
 - a. FUNCTION Reference
 - b. Exponentiation (**)
 - c. Multiplication and Division (* and /)
 - d. Addition and Subtraction (+ and -)
 - e. .LT., .LE., .EQ., .NE., .GT., .GE.
 - f. .NOT.
 - g. .AND.
 - h. .OR., .XOR.

Examples:

The expression

X .AND. Y .OR. B(3,2) .GT. Z

is evaluated as

e1 = B(3,2).GT.Z
e2 = X .AND. Y
e3 = e2 .OR. e1

The expression

X .AND. (Y .OR. B(3,2) .GT. Z)

is evaluated as

e1 = B(3,2) .GT. Z
e2 = Y .OR. e1
e3 = X .AND. e2

3. It is invalid to have two contiguous logical operators except when the second operator is .NOT. That is,

.AND..NOT.

and

.OR..NOT.

are permitted.

Example:

A.AND..NOT.B is permitted

A.AND..OR.B is not permitted

4.4 HOLLERITH, LITERAL, AND HEXADECIMAL CONSTANTS IN EXPRESSIONS

Hollerith, Literal, and Hexadecimal constants are allowed in expressions in place of Integer constants. These special constants always evaluate to an Integer value and are therefore limited to a length of two bytes. The only exceptions to this are:

1. Long Hollerith or Literal constants may be used as subprogram parameters.
2. Hollerith, Literal, or Hexadecimal constants may be up to four bytes long in DATA statements when associated with Real variables, or up to eight bytes long when associated with Double Precision variables.

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SECTION 5

REPLACEMENT STATEMENTS

Replacement statements define computations and are used similarly to equations in normal mathematical notation. They are of the following form:

$$v = e$$

where v is any variable or array element and e is an expression.

FORTTRAN semantics defines the equality sign (=) as meaning to be replaced by rather than the normal is equivalent to. Thus, the object program instructions generated by a replacement statement will, when executed, evaluate the expression on the right of the equality sign and place that result in the storage space allocated to the variable or array element on the left of the equality sign.

The following conditions apply to replacement statements:

1. Both v and the equality sign must appear on the same line. This holds even when the statement is part of a logical IF statement (section 7).

Example:

```
C IN A REPLACEMENT STATEMENT THE '='  
C   MUST BE IN THE INITIAL LINE.  
  A(5,3) =  
1     B(7,2) + SIN(C)
```

The line containing $v=$ must be the initial line of the statement unless the statement is part of a logical IF statement. In that case the $v=$ must occur no later than the end of the first line after the end of the IF.

2. If the data types of the variable, v , and the expression, e , are different, then the value determined by the expression will be converted, if possible, to conform to the typing of the variable. Table 5-1 shows which type expressions may be equated to which type of variable. Y indicates a valid replacement and N indicates an invalid replacement. Footnotes to Y indicate conversion considerations.

Table 5-1. Replacement By Type

Variable Types	Expression Types (e)				
	Integer	Real	Logical	Double	Ext Int
Integer	Y	Ya	Yb	Ya	Yg
Real	Yc	Y	Yc	Ye	Yc
Logical	Yd	Ya	Y	Ya	Yd
Double	Yc	Y	Yc	Y	Yc
Ext Int	Yf	Yh	Yb,f	Yh	Y

- a. The Real expression value is converted to Integer, truncated if necessary to conform to the range of Integer data.
- b. The sign is extended through the second byte.
- c. The variable is assigned the Real approximation of the Integer value of the expression.
- d. The variable is assigned the truncated value of the Integer expression (the low-order byte is used, regardless of sign).
- e. The variable is assigned the rounded value of the Real expression.
- f. The sign is extended through the third and fourth bytes.
- g. The variable is assigned the truncated value of the Extended Integer expression.
- h. The expression value is converted to Extended Integer and truncated to conform to the range of Extended Integer data.

SECTION 6

SPECIFICATION STATEMENTS

Specification statements are non-executable, non-generative statements which define data types of variables and arrays, specify array dimensionality and size, allocate data storage or otherwise supply determinative information to the FORTRAN processor. DATA initialization statements are non-executable, but generate object program data and establish initial values for variable data.

6.1 SPECIFICATION STATEMENTS

There are seven kinds of specification statements. They are as follows:

- IMPLICIT statements
- Type, EXTERNAL, and DIMENSION statements
- COMMON statements
- EQUIVALENCE statements
- DATA initialization statements

All specification statements are grouped at the beginning of a program unit and must be ordered as they appear above. Specification statements may be preceded only by a FUNCTION, SUBROUTINE, PROGRAM or BLOCK DATA statement. All specification statements must precede statement functions and the first executable statement.

6.2 ARRAY DECLARATORS

Three kinds of specification statements may specify array declarators. These statements are the following:

- Type statements
- DIMENSION statements
- COMMON statements

Of these, DIMENSION statements have the declaration of arrays as their sole function. The other two serve dual purposes. These statements are defined in subparagraphs 6.3, 6.5 and 6.6.

Array declarators are used to specify the name, dimensionality and sizes of arrays. An array may be declared only once in a program unit.

An array declarator has one of the following forms:

```
ui (k)
ui (k1,k2)
ui (k1,k2,k3)
```

where ui is the name of the array, called the declarator name, and the k's are integer constants.

Array storage allocation is established upon appearance of the array declarator. Such storage is allocated linearly by the FORTRAN processor where the order of ascendancy is determined by the first subscript varying most rapidly and the last subscript varying least rapidly.

For example, if the array declarator AMAT(3,2,2) appears, storage is allocated for the 12 elements in the following order:

```
AMAT(1,1,1), AMAT(2,1,1), AMAT(3,1,1), AMAT(1,2,1),
AMAT(2,2,1), AMAT(3,2,1), AMAT(1,1,2), AMAT(2,1,2),
AMAT(3,1,2), AMAT(1,2,2), AMAT(2,2,2), AMAT(3,2,2)
```

6.3 TYPE STATEMENTS

Variable, array and FUNCTION names are automatically typed Integer or Real by the 'predefined' convention unless they are changed by Type statements. For example, the type is Integer if the first letter of an item is I, J, K, L, M or N. Otherwise, the type is Real.

Type statements provide for overriding or confirming the pre-defined convention by specifying the type of an item. In addition, these statements may be used to declare arrays.

Type statements have the following general form:

```
t v1,v2,...vn
```

where t represents one of the terms INTEGER, INTEGER*1, INTEGER*2, INTEGER*4, REAL, REAL*4, REAL*8, DOUBLE PRECISION, LOGICAL, LOGICAL*1, LOGICAL*2, LOGICAL*4, or BYTE. Each v is an array declarator or a variable, array or FUNCTION name. The INTEGER*1, INTEGER*2, INTEGER*4, REAL*4, REAL*8, LOGICAL*1, LOGICAL*2, LOGICAL*4 types are allowed for readability and compatibility with other FORTRANs.

Example:

```
REAL AMAT(3,3,5),BX,IETA,KLPH
```

NOTE

1. AMAT and BX are redundantly typed.
2. IETA and KLPH are unconditionally declared Real.
3. AMAT(3,3,5) is a constant array declarator specifying an array of 45 elements.

Example:

```
INTEGER M1, HT, JMP(15), FL
```

NOTE

M1 is redundantly typed here. Typing of HT and FL by the pre-defined convention is overridden by their appearance in the INTEGER statement. JMP(15) is a constant array declarator. It redundantly types the array elements as Integer and communicates to the processor the storage requirements and dimensionality of the array.

Example:

```
LOGICAL L1, TEMP
```

NOTE

All variables, arrays or FUNCTIONS required to be typed Logical must appear in a LOGICAL statement, since no starting letter indicates these types by the default convention.

6.4 EXTERNAL STATEMENTS

EXTERNAL statements have the following form:

```
EXTERNAL u1,u2,...,un
```

where each u_i is a SUBROUTINE, BLOCK DATA or FUNCTION name. When the name of a subprogram is used as an argument in a subprogram reference, it must have appeared in a preceding EXTERNAL statement.

When a BLOCK DATA subprogram is to be included in a program load, its name must have appeared in an EXTERNAL statement within the main program unit.

For example, if SUM and AFUNC are subprogram names to be used as arguments in the subroutine SUBR, the following statements would appear in the calling program unit:

```
.  
.   
.   
EXTERNAL SUM, AFUNC  
.   
.   
.   
CALL SUBR(SUM,AFUNC,X,Y)
```

6.5 DIMENSION STATEMENTS

A DIMENSION statement has the following form:

```
DIMENSION u1,u2,u3,...,un
```

where each u_i is an array declarator.

Example:

```
DIMENSION RAT(5,5),BAR(20)
```

This statement declares two arrays - the 25 element array RAT and the 20 element array BAR.

6.6 COMMON STATEMENTS

COMMON statements are non-executable, storage allocating statements which assign variables and arrays to a storage area called COMMON storage and provide the facility for various program units to share the use of the same storage area.

COMMON statements are expressed in the following form:

```
COMMON /y1/a1/y2/a2/.../yn/an
```

where each y_i is a COMMON block storage name and each a_i is a sequence of variable names, array names or constant array declarators, separated by commas. The elements in a_i make up the COMMON block storage area specified by the name y_i . If any y_i is omitted leaving two consecutive slash characters (//), the block of storage so indicated is called blank COMMON. If the first block name (y_1) is omitted, the two slashes may be omitted.

Example:

```
COMMON /AREA/A,B,C/BDATA/X,Y,Z,  
X                      FL,ZAP(30)
```

In this example, two blocks of COMMON storage are allocated - AREA with space for three variables and BDATA, with space for four variables and the 30 element array, ZAP.

Example:

```
COMMON //A1,B1/CDATA/ZOT(3,3)  
X                      //T2,Z3
```

In this example, A1, B1, T2 and Z3 are assigned to blank COMMON in that order. The pair of slashes preceding A1 could have been omitted.

CDATA names COMMON block storage for the nine element array, ZOT and thus ZOT (3,3) is an array declarator. ZOT must not have been previously declared. (See "Array Declarators," Paragraph 6.3.)

Additional Considerations:

1. The name of a COMMON block may appear more than once in the same COMMON statement, or in more than one COMMON statement.

2. A COMMON block name is made up of from 1 to 6 alphanumeric characters, the first of which must be a letter.
3. A COMMON block name must be different from any subprogram names used throughout the program.
4. The size of a COMMON area may be increased by the use of EQUIVALENCE statements. See "EQUIVALENCE Statements," Paragraph 6.7.
5. The lengths of COMMON blocks of the same name need not be identical in all program units where the name appears. However, if the lengths differ, the program unit specifying the greatest length must be loaded first (see the discussion of LINK-80 in the User's Guide). The length of a COMMON area is the number of storage units required to contain the variables and arrays declared in the COMMON statement (or statements) unless expanded by the use of EQUIVALENCE statements.

6.7 EQUIVALENCE STATEMENTS

Use of EQUIVALENCE statements permits the sharing of the same storage unit by two or more entities. The general form of the statement is as follows:

EQUIVALENCE (u1),(u2),...,(un)

where each u_i represents a sequence of two or more variables or array elements, separated by commas. Each element in the sequence is assigned the same storage unit (or portion of a storage unit) by the processor. The order in which the elements appear is not significant.

Example:

EQUIVALENCE (A,B,C)

The variables A, B and C will share the same storage unit during object program execution.

If an array element is used in an EQUIVALENCE statement, the number of subscripts must be the same as the number of dimensions established by the array declarator, or it must be one, where the one subscript specifies the array element's number relative to the first element of the array.

Example:

If the dimensionality of an array, Z, has been declared as Z(3,3) then in an EQUIVALENCE statement Z(6) and Z(3,2) have the same meaning.

Additional Considerations:

1. The subscripts of array elements must be integer constants.
2. An element of a multi-dimensional array may be referred to by a single subscript, if desired.
3. Variables may be assigned to a COMMON block through EQUIVALENCE statements.

Example:

```
COMMON /X/A,B,C
EQUIVALENCE (A,D)
```

In this case, the variables A and D share the first storage unit in COMMON block X.

4. EQUIVALENCE statements can increase the size of a block indicated by a COMMON statement by adding more elements to the end of the block.

Example:

```
DIMENSION R(2,2)
COMMON /Z/W,X,Y
EQUIVALENCE (Y,R(3))
```

The resulting COMMON block will have the following configuration:

Variable Storage Unit

W = R(1,1)	0
X = R(2,1)	1
Y = R(1,2)	2
R(2,2)	3

The COMMON block established by the COMMON statement contains 3 storage units. It is expanded to 4 storage units by the EQUIVALENCE statement.

COMMON block size may be increased only from the last element established by the COMMON statement forward; not from its first element backward.

Note that EQUIVALENCE (X,R(3)) would be invalid in the example. The COMMON statement established W as the first element in the COMMON block and an attempt to make X and R(3) equivalent would be an attempt to make R(1) the first element.

5. It is invalid to EQUIVALENCE two elements of the same array or two elements belonging to the same or different COMMON blocks.

Example:

```

      DIMENSION XTABLE (20), D(5)
      COMMON A,B(4)/ZAP/C,X
      .
      .
      EQUIVALENCE (XTABLE (6),A(7),
X          B(3),XTABLE(15)),
Y          (B(3),D(5))
      .
      .
      .

```

This EQUIVALENCE statement has the following errors:

1. It attempts to EQUIVALENCE two elements of the same array, XTABLE(6) and XTABLE(15).
2. It attempts to EQUIVALENCE two elements of the same COMMON block, A(7) and B(3).
3. Since A is not an array, A(7) is an illegal reference.
4. Making B(3) equivalent to D(5) extends COMMON backwards from its defined starting point.

6.8 DATA INITIALIZATION STATEMENT

The DATA initialization statement is a non-executable statement which provides a means of compiling data values into the object program and assigning these data to variables and array elements referenced by other statements.

The statement is of the following form:

```
DATA list/u1,u2,...,un/,list.../uk,uk+1,...uk+n/
```

where "list" represents a list of variable, array or array element names, and the ui are constants

corresponding in number to the elements in the list. An exception to the one-for-one correspondence of list items to constants is that an array name (unsubscripted) may appear in the list, and as many constants as necessary to fill the array may appear in the corresponding position between slashes. Instead of *ui*, it is permissible to write *k*ui* in order to declare the same constant, *ui*, *k* times in succession. *k* must be a positive integer. Dummy arguments may not appear in the list.

Example:

```
DIMENSION C(7)
DATA A, B, C(1),C(3)/14.73,
X      -8.1,2*7.5/
```

This implies that

A=14.73, B=-8.1, C(1)=7.5, C(3)=7.5

The type of each constant *ui* must match the type of the corresponding item in the list, except that a Hollerith or Literal constant may be paired with an item of any type.

When a Hollerith or Literal constant is used, the number of characters in its string should be no greater than four times the number of storage units required by the corresponding item, i.e., 1 character for a Logical variable, up to 2 characters for an Integer variable and 4 or fewer characters for a Real variable.

If fewer Hollerith or Literal characters are specified, trailing blanks are added to fill the remainder of storage.

Hexadecimal data are stored in a similar fashion. If fewer Hexadecimal characters are used, sufficient leading zeros are added to fill the remainder of the storage unit.

The examples below illustrate many of the features of the DATA statement.

```

      DIMENSION HARY (2)
      DATA HARY,B/ 4HTHIS, 4H OK.
1      ,7.86/

```

```

      REAL LIT(2)
      LOGICAL LT,LF
      DIMENSION H4(2,2),PI3(3)
      DATA A1,B1,K1,LT,LF,H4(1,1),H4(2,1),
1      H4(1,2),H4(2,2),PI3/5.9,2.5E-4,
2      64,.FALSE.,.TRUE.,1.75E-3,
3      0.85E-1,2*75.0,1.,2.,3.14159/,
4      LIT(1)/'NOGO'/

```

6.9 IMPLICIT STATEMENT

The IMPLICIT statement is used to redefine default variable types. The syntax is:

```
IMPLICIT type(range),type(range),...
```

where type is one of the following: INTEGER, REAL, LOGICAL, DOUBLE PRECISION, BYTE, INTEGER*1, INTEGER*2, INTEGER*4, REAL*4, REAL*8

and range is a list of alphabetic characters separated by commas or hyphens.

Examples:

```
IMPLICIT INTEGER(A,W-Z),REAL(B-V)
```

All variables (not otherwise declared) starting with the letters A, W, X, Y, Z will be type INTEGER. All variables starting with the letters B through V will be type REAL.

```
IMPLICIT INTEGER(I-N),REAL(A-H,O-Z)
```

This is the default definition.

Any IMPLICIT statements must appear in a program grouped with the Type and DIMENSION statements. IMPLICIT statements must appear before any other specification statements. If the IMPLICIT statement appears after any Type or DIMENSION statements, the types of the variables already declared will not be affected.

SECTION 7

FORTRAN CONTROL STATEMENTS

FORTRAN control statements are executable statements which affect and guide the logical flow of a FORTRAN program. The statements in this category are as follows:

1. GO TO statements:
 1. Unconditional GO TO
 2. Computed GO TO
 3. Assigned GO TO
2. ASSIGN
3. IF statements:
 1. Arithmetic IF
 2. Logical IF
4. DO
5. CONTINUE
6. STOP
7. PAUSE
8. CALL
9. RETURN
10. END

When statement labels of other statements are a part of a control statement, such statement labels must be associated with executable statements within the same program unit in which the control statement appears.

7.1 GO TO STATEMENTS

7.1.1 UNCONDITIONAL GO TO

Unconditional GO TO statements are used whenever control is to be transferred unconditionally to some other statement within the program unit.

The statement is of the following form:

GO TO k

where k is the statement label of an executable statement in the same program unit.

Example:

```
      GO TO 376
310   A(7) = V1 -A(3)
      .
      .
376   A(2) =VECT
      GO TO 310
```

In these statements, statement 376 is ahead of statement 310 in the logical flow of the program of which they are a part.

7.1.2 COMPUTED GO TO

Computed GO TO statements are of the form:

GO TO (k1,k2,...,n),j

where the k_i are statement labels, and j is an integer variable, $1 \leq j \leq n$.

This statement causes transfer of control to the statement labeled k_j . If $j \leq 1$ or $j > n$, control will be passed to the next statement following the Computed GOTO.

Example:

```
      J=3
      .
      .
      .
      GO TO(7, 70, 700, 7000, 70000), J
310   J=5
      GO TO 325
```

When $J = 3$, the computed GO TO transfers control to statement 700. Changing J to equal 5 changes the transfer to statement 70000. Making $J = 0$ or $J = 6$ would cause control to be transferred to statement 310.

7.1.3 ASSIGNED GO TO

Assigned GO TO statements are of the following form:

GO TO j, (k1, k2, ..., kn)

or

GOTO J

where J is an integer variable name, and the k_i are statement labels of executable statements. This statement causes transfer of control to the statement whose label is equal to the current value of J.

Qualifications

1. The ASSIGN statement must logically precede an assigned GO TO.
2. The ASSIGN statement must assign a value to J which is a statement label included in the list of k's, if the list is specified.

Example:

GO TO LABEL, (80, 90, 100)

Only the statement labels 80, 90 or 100 may be assigned to LABEL.

7.2 ASSIGN STATEMENT

This statement is of the following form:

```
ASSIGN j TO i
```

where j is a statement label of an executable statement and i is an integer variable.

The statement is used in conjunction with each assigned GO TO statement that contains the integer variable i. When the assigned GO TO is executed, control will be transferred to the statement labeled j.

Example:

```
ASSIGN 100 TO LABEL  
.  
.  
.  
ASSIGN 90 TO LABEL  
GO TO LABEL, (80,90,100)
```

7.3 IF STATEMENT

IF statements transfer control to one of a series of statements depending upon a condition. Two types of IF statements are provided:

Arithmetic IF
Logical IF

7.3.1 ARITHMETIC IF

The arithmetic IF statement is of the form:

IF(e) m1,m2,m3

where e is an arithmetic expression and m1, m2 and m3 are statement labels.

Evaluation of expression e determines one of three transfer possibilities:

If e is:	Transfer to:
< 0	m1
= 0	m2
> 0	m3

Examples:

Statement	Expression Value	Transfer to
IF (A) 3,4,5	15	5
IF (N-1) 50,73,9	0	73
IF (AMTX(2,1,2)) 7,2,1	-256	7

7.3.2 LOGICAL IF

The Logical IF statement is of the form:

IF (u) s

where u is a Logical expression and s is any executable statement except a DO statement (see 7.4) or another Logical IF statement. The Logical expression u is evaluated as .TRUE. or .FALSE. Section 4 contains a discussion of Logical expressions.

Control Conditions:

If u is FALSE, the statement s is ignored and control goes to the next statement following the Logical IF statement. If, however, the expression is TRUE, then control goes to the statement s, and subsequent program control follows normal conditions.

If s is a replacement statement ($v = e$, Section 5), the variable and equality sign (=) must be on the same line, either immediately following IF(u) or on a separate continuation line with the line spaces following IF(u) left blank. See example 4 below.

Examples:

1. IF(I.GT.20) GO TO 115
2. IF(Q.AND.R) ASSIGN 10 TO J
3. IF(Z) CALL DECL(A,B,C)
4. IF(A.OR.B.LE.PI/2) I=J
5. IF(A.OR.B.LE.PI/2)
X I =J

7.4 DO STATEMENT

The DO statement, as implemented in FORTRAN, provides a method for repetitively executing a series of statements. The statement takes one of the two following forms:

1) DO k i = m1,m2,m3

or

2) DO k i = m1,m2

where k is a statement label, i is an integer or logical variable, and m1, m2 and m3 are integer constants or integer or logical variables.

If m3 is 1, it may be omitted as in 2) above.

The following conditions and restrictions govern the use of DO statements:

1. The DO and the first comma must appear on the initial line.
2. The statement labeled k, called the terminal statement, must be an executable statement.
3. The terminal statement must physically follow its associated DO, and the executable statements following the DO, up to and including the terminal statement, constitute the range of the DO statement.
4. The terminal statement may not be an Arithmetic IF, GO TO, RETURN, STOP, PAUSE or another DO.
5. If the terminal statement is a logical IF and its expression is .FALSE., then the statements in the DO range are reiterated.

If the expression is .TRUE., the statement of the logical IF is executed and then the statements in the DO range are reiterated. The statement of the logical IF may not be a GO TO, Arithmetic IF, RETURN, STOP or PAUSE.

6. The controlling integer variable, i, is called the index of the DO range. The index must be positive and may not be modified by any statement in the range.
7. If m1, m2, and m3 are Integer*1 variables or constants, the DO loop will execute faster and be shorter, but the range is limited to 127

iterations. For example, the loop overhead for a DO loop with a constant limit and an increment of 1 depends upon the type of the index variable as follows:

Index Variable Type	Overhead	
	Microseconds	Bytes
INTEGER*2	35.5	19
INTEGER*1	24	14

8. During the first execution of the statements in the DO range, i is equal to m_1 ; the second execution, $i = m_1 + m_3$; the third, $i = m_1 + 2 * m_3$, etc., until i is equal to the highest value in this sequence less than or equal to m_2 , and then the DO is said to be satisfied. The statements in the DO range will always be executed at least once, even if $m_1 \leq m_2$.

When the DO has been satisfied, control passes to the statement following the terminal statement, otherwise control transfers back to the first executable statement following the DO statement.

Example:

The following example computes

```
100
Sigma Ai where a is a one-dimensional array
i=1
```

```
100  DIMENSION A(100)
      .
      .
      .
      SUM = A(1)
      DO 31 I = 2,100
31   SUM =SUM + A(I)

      END
```

9. The range of a DO statement may be extended to include all statements which may logically be executed between the DO and its terminal statement. Thus, parts of the DO range may be situated such that they are not physically between the DO statement and its terminal statement but are executed logically in the DO range. This is called the extended range.

Example:

```
      DIMENSION A(500), B(500)
      .
      .
      .
      DO 50 I = 10, 327, 3
      .
      .
      .
      IF (V7 -C*C) 20,15,31
30      .
      .
      .
50     A(I) = B(I) + C
      .
      .
      .
20     C = C - .05
      GO TO 50
31     C=C+ .0125
      GO TO 30
```

10. It is invalid to transfer control into the range of a DO statement not itself in the range or extended range of the same DO statement.
11. Within the range of a DO statement, there may be other DO statements, in which case the DO's must be nested. That is, if the range of one DO contains another DO, then the range of the inner DO must be entirely included in the range of the outer DO.

The terminal statement of the inner DO may also be the terminal statement of the outer DO.

For example, given a two dimensional array A of 15 rows and 15 columns, and a 15 element one-dimensional array B, the following statements compute the 15 elements of array C to the formula:

$$C_k = \sum_{j=1}^{15} A_{kj} B_j, \quad k = 1, 2, \dots, 15$$

```

      DIMENSION A(15,15), B(15), C(15)
      .
      .
      .
      DO 80 K =1,15
      C(K) = 0.0
      DO 80 J=1,15
80    C(K) = C(K) +A(K,J) * B(J)
      .
      .
      .

```

7.5 CONTINUE STATEMENT

CONTINUE is classified as an executable statement. However, its execution does nothing. The form of the CONTINUE statement is as follows:

CONTINUE

CONTINUE is frequently used as the terminal statement in a DO statement range when the statement which would normally be the terminal statement is one of those which are not allowed or is only executed conditionally.

Example:

```

      DO 5 K = 1,10
      .
      .
      .
      IF (C2) 5,6,6
6    CONTINUE
      .
      .
      .
      C2 = C2 +.005
5    CONTINUE

```

7.6 STOP STATEMENT

A STOP statement has one of the following forms:

STOP

or

STOP c

where c is any string of one to six characters.

When STOP is encountered during execution of the object program, the characters c (if present) are displayed on the operator control console and execution of the program terminates.

The STOP statement, therefore, constitutes the logical end of the program.

7.7 PAUSE STATEMENT

A PAUSE statement has one of the following forms:

PAUSE

or

PAUSE c

where c is any string of up to six characters.

When PAUSE is encountered during execution of the object program, the characters c (if present) are displayed on the operator control console and execution of the program ceases.

The decision to continue execution of the program is not under control of the program. If execution is resumed through intervention of an operator without otherwise changing the state of the processor, the normal execution sequence, following PAUSE, is continued.

Execution may be terminated by typing a "T" at the operator console. Typing any other character will cause execution to resume.

7.8 CALL STATEMENT

CALL statements control transfers into SUBROUTINE subprograms and provide parameters for use by the subprograms. The general forms and detailed discussion of CALL statements appear in Section 9, FUNCTIONS AND SUBPROGRAMS.

7.9 RETURN STATEMENT

The form, use and interpretation of the RETURN statement is described in Section 9.

7.10 END STATEMENT

The END statement must physically be the last statement of any FORTRAN program. It has the following form:

END

The END statement is an executable statement and may have a statement label. It causes a transfer of control to be made to the system exit routine \$EX, which returns control to the operating system.

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SECTION 8

INPUT / OUTPUT

FORTRAN provides a series of statements which define the control and conditions of data transmission between computer memory and external data handling or mass storage devices such as magnetic tape, disk, line printer, punched card processors, keyboard printers, etc.

These statements are grouped as follows:

1. Formatted READ and WRITE statements which cause formatted information to be transmitted between the computer and I/O devices.
2. Unformatted READ and WRITE statements which transmit unformatted binary data in a form similar to internal storage.
3. Auxiliary I/O statements for positioning and demarcation of files.
4. ENCODE and DECODE statements for transferring data between memory locations.
5. FORMAT statements used in conjunction with formatted record transmission to provide data conversion and editing information between internal data representation and external character string forms.

8.1 FORMATTED READ/WRITE STATEMENTS

8.1.1 FORMATTED READ STATEMENTS

A formatted READ statement is used to transfer information from an input device to the computer.

Two forms of the statement are available, as follows:

```
READ (u,f,ERR=L1,END=L2) k
```

or

```
READ (u,f,ERR=L1,END=L2)
```

where:

u - specifies a Physical and Logical Unit Number and may be either an unsigned integer or an integer variable in the range 1 through 10. If an Integer variable is used, an Integer value must be assigned to it prior to execution of the READ statement.

Units 1, 3, 4, and 5 are preassigned to the console Teletypewriter. Unit 2 is preassigned to the Line Printer (if one exists). Units 6-10 are preassigned to Disk Files (see User's Manual, Section 3). These units, as well as units 11-255, may be re-assigned by the user (see Appendix B).

f - is the statement label of the FORMAT statement describing the type of data conversion to be used within the input transmission or it may be an array name, in which case the formatting information may be input to the program at the execution time. (See Section 8.7.10)

L1- is the FORTRAN label on the statement to which the I/O processor will transfer control if an I/O error is encountered.

L2- is the FORTRAN label on the statement to which the I/O processor will transfer control if an End-of-File is encountered.

k - is a list of variable names, separated by commas, specifying the input data.

READ (u,f)k is used to input a number of items, corresponding to the names in the list k, from the file on logical unit u, and using the FORMAT statement f to specify the external representation of these items (see FORMAT statements, 8.7). The ERR= and END= clauses are optional. If not specified, I/O errors and End-of-Files cause fatal runtime errors.

The following notes further define the function of the READ (u,f)k statement:

1. Each time execution of the READ statement begins, a new record from the input file is read.
2. The number of records to be input by a single READ statement is determined by the list, k, and format specifications.
3. The list k specifies the number of items to be read from the input file and the locations into which they are to be stored.
4. Any number of items may appear in a single list and the items may be of different data types.
5. If there are more quantities in an input record than there are items in the list, only the number of quantities equal to the number of items in the list are transmitted. Remaining quantities are ignored.
6. Exact specifications for the list k are described in 8.6.

Examples:

1. Assume that four Integer data entries are stored in a sequential disk file and that the values have field widths of 3, 4, 2 and 5 respectively. The statements

```
      READ(5,20)K,L,M,N  
20 FORMAT(I3,I4,I2,I5)
```

will read the file and assign the input data to the variables K, L, M and N.

See 8.7 for complete description of FORMAT statements.

2. Input the quantities of an array (ARRY):

```
READ(6,21) ARRY
```

Only the name of the array needs to appear in the list (see 8.6). All elements of the array ARRY will be read and stored using the appropriate formatting specified by the FORMAT statement labeled 21.

READ(u,k) may be used in conjunction with a FORMAT statement to read H-type alphanumeric data into an existing H-type field (see Hollerith Conversions, 8.7.3).

For example, the statements

```
      READ(I,25)  
      .  
      .  
      .  
25  FORMAT(10HABCDEFGH IJ)
```

cause the next 10 characters of the file on input device I to be read and replace the characters ABCDEFGHIJ in the FORMAT statement.

8.1.2 FORMATTED WRITE STATEMENTS

A formatted WRITE statement is used to transfer information from the computer to an output device.

Two forms of the statement are available, as follows:

```
WRITE(u,f,ERR=L1,END=L2) k
```

or

```
WRITE (u,f,ERR=L1,END=L2)
```

where:

u - specifies a Logical Unit Number.

f - is the statement label of the FORMAT statement describing the type of data conversion to be used with the output transmission.

L1- specifies an I/O error branch.

L2- specifies an EOF branch.

k - is a list of variable names separated by commas, specifying the output data.

WRITE (u,f)k is used to output the data specified in the list k to a file on logical unit u using the FORMAT statement f to specify the external representation of the data (see FORMAT statements, 8.7). The following notes further define the function of the WRITE statement:

1. Several records may be output with a single WRITE statement, with the number determined by the list and FORMAT specifications.
2. Successive data are output until the data specified in the list are exhausted.
3. If output is to a device which specifies fixed length records and the data specified in the list do not fill the record, the remainder of the record is filled with blanks.

Example:

```
WRITE(2,10) A,B,C,D
```

The data assigned to the variables A, B, C and D are output to Logical Unit Number 2, formatted according to the FORMAT statement labeled 10.

WRITE(u,f) may be used to write alphanumeric information when the characters to be written are specified within the FORMAT statement. In this case a variable list is not required.

For example, to write the characters 'H CONVERSION' on unit 1,

```
      WRITE(1,26)
      .
      .
      .
26 FORMAT ('H CONVERSION')
```

8.2 UNFORMATTED READ/WRITE

Unformatted I/O (i.e. without data conversion) is accomplished using the statements:

```
READ(u,ERR=L1,END=L2) k
```

```
WRITE(u,ERR=L1,END=L2) k
```

where:

u - specifies a Logical Unit Number.

L1- specifies an I/O error branch.

L2- specifies an EOF branch.

k - is a list of variable names, separated by commas, specifying the I/O data.

The following notes define the functions of unformatted I/O statements.

1. Unformatted READ/WRITE statements perform memory-image transmission of data with no data conversion or editing.
2. The amount of data transmitted corresponds to the number of variables in the list k.
3. The total length of the list of variable names in an unformatted READ must not be longer than the record length. If the logical record length and the length of the list are the same, the entire record is read. If the length of the list is shorter than the logical record length the unread items in the record are skipped.

4. The WRITE(a)k statement writes one logical record.
5. A logical record may extend across more than one physical record.

8.3 DISK FILE I/O

A READ or WRITE to a disk file (LUN 6-10) automatically OPENS the file for I/O. The file remains open until closed by an ENDFILE command (see Section 8.4) or until normal program termination.

NOTE

Exercise caution when doing sequential output to disk files. If output is done to an existing file, the existing file will be deleted and replaced with a new file of the same name.

8.3.1 RANDOM DISK I/O

SEE ALSO SECTION 3 OF YOUR MICROSOFT FORTRAN USER'S MANUAL.

For random disk access, the record number is specified by using the REC=n option in the READ or WRITE statement. For example:

```
      I = 10
      WRITE (6,20,REC=I,ERR=50) X, Y, Z
      .
      .
      .
```

This program segment writes record 10 on LUN 6. If a previous record 10 exists, it is written over. If no record 10 exists, the file is extended to create one. Any attempt to read a non-existent record results in an I/O error.

8.3.2 OPEN SUBROUTINE

Alternatively, a file may be OPENed using the OPEN subroutine. LUNs 1-5 may also be assigned to disk files with OPEN. The OPEN subroutine allows the program to specify a filename and device to be associated with a LUN.

An OPEN of a non-existent file creates a null file of the appropriate name. An OPEN of an existing file followed by sequential output deletes the existing file. An OPEN of an existing file followed by an input allows access to the current contents of the file.

The form of an OPEN call varies under different operating systems. See your Microsoft FORTRAN User's Manual, Section 3.

8.4 AUXILIARY I/O STATEMENTS

Three auxiliary I/O statements are provided:

```
BACKSPACE u
REWIND u
ENDFILE u
```

The actions of all three statements depend on the LUN with which they are used (see Appendix B). When the LUN is for a terminal or line printer, the three statements are defined as no-ops.

When the LUN is for a disk drive, the ENDFILE and REWIND commands allow further program control of disk files. ENDFILE u closes the file associated with LUN u. REWIND u closes the file associated with LUN u, then opens it again. BACKSPACE is not implemented at this time, and therefore causes an error if used.

8.5 ENCODE/DECODE

ENCODE and DECODE statements transfer data, according to format specifications, from one section of memory to another. DECODE changes data from ASCII format to the specified format. ENCODE changes data of the specified format into ASCII format. The two statements are of the form:

```
ENCODE(a,f) k  
DECODE(a,f) k
```

where:

```
a is an array name  
f is FORMAT statement number  
k is an I/O List
```

DECODE is analogous to a READ statement, since it causes conversion from ASCII to internal format. ENCODE is analogous to a WRITE statement, causing conversion from internal formats to ASCII.

NOTE

Care should be taken that the array A is always large enough to contain all of the data being processed. There is no check for overflow. An ENCODE operation which overflows the array will probably wipe out important data following the array. A DECODE operation which overflows will attempt to process the data following the array.

8.6 INPUT/OUTPUT LIST SPECIFICATIONS

Most forms of READ/WRITE statements may contain an ordered list of data names which identify the data to be transmitted. The order in which the list items appear must be the same as that in which the corresponding data exists (Input), or will exist (Output) in the external I/O medium.

Lists have the following form:

```
m1,m2,...,mn
```

where the m_i are list items separated by commas, as shown.

8.6.1 LIST ITEM TYPES

A list item may be a single datum identifier or a multiple data identifier.

1. A single datum identifier item is the name of a variable or array element.

Examples:

```
A
C(26,1),R,K,D
B,I(10,10),S,F(1,25)
```

NOTE

Sublists are not implemented.

2. Multiple data identifier items are in two forms:

- a. An array name appearing in a list without subscript(s) is considered equivalent to the listing of each successive element of the array.

Example:

If B is a two dimensional array, the list item B is equivalent to: B(1,1),B(2,1),B(3,1)...., B(1,2),B(2,2)....,B(j,k).

where j and k are the subscript limits of B.

- b. DO-implied items are lists of one or more single datum identifiers or other DO-implied items followed by a comma character and an expression of the form:

i = m1,m2,m3 or i = m1,m2

and enclosed in parentheses.

The elements i,m1,m2,m3 have the same meaning as defined for the DO statement. The DO implication applies to all list items enclosed in parentheses with the implication.

Examples:

DO-Implied Lists

```
(X(I), I=1,4)
(Q(J), R(J), J=1,2)
(G(K), K=1,7,3)
((A(I,J), I=3,5), J=1,9,4)

(R(M), M=1,2), I, ZAP(3)
(R(3), T(I), I=1,3)
```

Equivalent Lists

```
X(1), X(2), X(3), X(4)
Q(1), R(1), Q(2), R(2)
G(1), G(4), G(7)
A(3,1), A(4,1), A(5,1)
A(3,5), A(4,5), A(5,5)
A(3,9), A(4,9), A(5,9)
R(1), R(2), I, ZAP(3)
R(3), T(1), R(3), T(2),
R(3), T(3)
```

Thus, the elements of a matrix, for example, may be transmitted in an order different from the order in which they appear in storage. The array A(3,3) occupies storage in the order A(1,1), A(2,1), A(3,1), A(1,2), A(2,2), A(3,2), A(1,3), A(2,3), A(3,3). By specifying the transmission of the array with the DO-implied list item ((A(I,J), J=1,3), I=1,3), the order of transmission is:

```
A(1,1), A(1,2), A(1,3), A(2,1), A(2,2),
A(2,3), A(3,1), A(3,2), A(3,3)
```

8.6.2 SPECIAL NOTES ON LIST SPECIFICATIONS

1. The ordering of a list is from left to right with repetition of items enclosed in parentheses (other than as subscripts) when accompanied by controlling DO-implied index parameters.
2. Arrays are transmitted by the appearance of the array name (unsubscripted) in an input/output list.
3. Constants may appear in an input/output list only as subscripts or as indexing parameters.
4. For input lists, the DO-implying elements i, m1, m2 and m3 may not appear within the parentheses as list items.

Examples:

1. READ (1,20) (I,J,A(I), I=1,J,2) is not allowed
2. READ(1,20) I,J, (A(I), I=1,J,2) is allowed

3. `WRITE(1,20) (I,J,A(I),I=1,J,2)` is allowed

Consider the following examples:

```
DIMENSION A(25)

A(1) = 2.1
A(3) = 2.2
A(5) = 2.3
J = 5

WRITE (1,20) J, (I,A(I),I=1,J,2)
.
.
.
```

the output of this WRITE statement is

```
5,1,2.1,3,2.2,5,2.3
```

1. Any number of items may appear in a single list.
2. In a formatted transmission (`READ(u,f)k`, `WRITE(u,f)k`) each item must have the correct type as specified by a `FORMAT` statement.

8.7 FORMAT STATEMENTS

`FORMAT` statements are non-executable, generative statements used in conjunction with formatted `READ` and `WRITE` statements. They specify conversion methods and data editing information as the data is transmitted between computer storage and external media representation.

`FORMAT` statements require statement labels for reference (f) in the `READ(u,f)k` or `WRITE(u,f)k` statements.

The general form of a `FORMAT` statement is as follows:

```
m FORMAT (s1,s2,...,sn/s1',s2',...,sn'/...)
```

where `m` is the statement label and each `si` is a field descriptor. The word `FORMAT` and the parentheses must be present as shown. The slash (/) and comma (,) characters are field separators and are described in a separate subparagraph. The field is defined as that part of an external record occupied by one transmitted item.

8.7.1 FIELD DESCRIPTORS

Field descriptors describe the sizes of data fields and specify the type of conversion to be exercised upon each transmitted datum. The FORMAT field descriptors may have any of the following forms:

Descriptor	Classification
rFw.d rGw.d rEw.d rDw.d rIw	Numeric Conversion
rLw	Logical Conversion
rAw nHh1h2...hn '1112...1n'	Hollerith Conversion
nX mP	Spacing Specification Scaling Factor

where:

1. w and n are positive integer constants defining the field width (including digits, decimal points, algebraic signs) in the external data representation.
2. d is an integer specifying the number of fractional digits appearing in the external data representation.
3. The characters F, G, E, D, I, A and L indicate the type of conversion to be applied to the items in an input/output list.
4. r is an optional, non-zero integer indicating that the descriptor will be repeated r times.
5. The hi and li are characters from the FORTRAN character set.
6. m is an integer constant (positive, negative, or zero) indicating scaling.

8.7.2 NUMERIC CONVERSIONS

Input operations with any of the numeric conversions will allow the data to be represented in a "Free Format"; i.e., commas may be used to separate the fields in the external representation.

F-type conversion

Form: Fw.d

Real or Double Precision type data are processed using this conversion. w characters are processed of which d are considered fractional.

F-output

Values are converted and output as minus sign (if negative), followed by the integer portion of the number, a decimal point and d digits of the fractional portion of the number. If a value does not fill the field, it is right justified in the field and enough preceding blanks to fill the field are inserted. If a value requires more field positions than allowed by w, the first w-1 digits of the value are output, preceded by an asterisk.

F-Output Examples:

FORMAT Descriptor	Internal Value	Output (b=blank)
F10.4	368.42	bb368.4200
F7.1	-4786.361	-4786.4
F8.4	8.7E-2	bb0.0870
F6.4	4739.76	*.7600
F7.3	-5.6	b-5.600

* Note the loss of leading digits in the 4th line above.

F-Input

(See the description under E-Input below.)

E-type Conversion

Form: Ew.d

Real or Double Precision type data are processed using this conversion. w characters are processed of which d are considered fractional.

E-Output

Values are converted, rounded to d digits, and output as:

1. a minus sign (if negative),
2. a zero and a decimal point,
3. d decimal digits,
4. the letter E,
5. the sign of the exponent (minus or blank),
6. two exponent digits,

in that order. The values as described are right justified in the field w with preceding blanks to fill the field if necessary. The field width w should satisfy the relationship:

$$w > d + 7$$

Otherwise significant characters may be lost. Some E-Output examples follow:

FORMAT Descriptor	Internal Value	Output (b=blank)
E12.5	76.573	bb.76573Eb02
E14.7	-32672.354	-b.3267235Eb05
E13.4	-0.0012321	bb-b.1232E-02
E8.2	76321.73	b.76Eb05

E-Input

Data values which are to be processed under E, F, or G conversion can be a relatively loose format in the external input medium. The format is identical for either conversion and is as follows:

1. Leading spaces (ignored)
2. A + or - sign (an unsigned input is assumed to be positive)
3. A string of digits
4. A decimal point
5. A second string of digits

6. The character E
7. A + or - sign
8. A decimal exponent

Each item in the list above is optional; but the following conditions must be observed:

1. If FORMAT items 3 and 5 (above) are present, then 4 is required.
2. If FORMAT item 8 is present, then 6 or 7 or both are required.
3. All non-leading spaces are considered zeros.

Input data can be any number of digits in length, and correct magnitudes will be developed, but precision will be maintained only to the extent specified in Section 3 for Real data.

E- and F- and G- Input Examples:

FORMAT Descriptor	Input (b=blank)	Internal Value
E10.3	+0.23756+4	+2375.60
E10.3	bbbbbb17631	+17.631
G8.3	b1628911	+1628.911
F12.4	bbbb-6321132	-632.1132

Note in the above examples that if no decimal point is given among the input characters, the d in the FORMAT specification establishes the decimal point in conjunction with an exponent, if given. If a decimal point is included in the input characters, the d specification is ignored.

The letters E, F, and G are interchangeable in the input format specifications. The end result is the same.

D-Type Conversions

D-Input and D-Output are identical to E-Input and E-Output except the exponent may be specified with a "D" instead of an "E."

G-Type Conversions

Form: Gw.d

Real or Double Precision type data are processed using this conversion. w characters are processed of which d are considered significant.

G-Input:

(See the description under E-Input)

G-Output:

The method of output conversion is a function of the magnitude of the number being output. Let n be the magnitude of the number. The following table shows how the number will be output:

<u>Magnitude</u>	<u>Equivalent Conversion</u>
$.1 \leq n < 1$	F(w-4).d,4X
$1 \leq n < 10$	F(w-4).(d-1),4X
.	.
.	.
.	.
$10^{d-2} \leq n < 10^{d-1}$	F(w-4).1,4X
$10^{d-1} \leq n < 10^d$	F(w-4).0,4X
Otherwise	Ew.d

I-Conversions

Form: Iw

Only Integer data may be converted by this form of conversion. w specifies field width.

I-Output:

Values are converted to Integer constants. Negative values are preceded by a minus sign. If the value does not fill the field, it is right justified in the field and enough preceding blanks to fill the field are inserted. If the value exceeds the field width, only the least significant w-1 characters are output preceded by an asterisk.

Examples:

FORMAT Descriptor	Internal Value	Output (b=blank)
I6	+281	bbb281
I6	-23261	-23261
I3	126	126
I4	-226	-226

I-Input:

A field of w characters is input and converted to internal integer format. A minus sign may precede the integer digits. If a sign is not present, the value is considered positive.

Integer values in the range -32768 to 32767 are accepted. Non-leading spaces are treated as zeros.

Examples:

Format Descriptor	Input (b=blank)	Internal Value
I4	b124	124
I4	-124	-124
I7	bb6732b	67320
I4	1b2b	1020

8.7.3 HOLLERITH CONVERSIONSA-Type Conversion

The form of the A conversion is as follows:

Aw

This descriptor causes unmodified Hollerith characters to be read into or written from a specified list item.

The maximum number of actual characters which may be transmitted between internal and external representations using Aw is four times the number of storage units in the corresponding list item (i.e., 1 character for logical items, 2 characters for Integer items, 4 characters for Real items and 8 characters for Double Precision items).

A-Output:

If w is greater than 4n (where n is the number of storage units required by the list item), the

external output field will consist of $w-4n$ blanks followed by the $4n$ characters from the internal representation. If w is less than $4n$, the external output field will consist of the leftmost w characters from the internal representation.

Examples:

Format Descriptor	Internal	Type	Output (b=blanks)
A1	A1	Integer	A
A2	AB	Integer	AB
A3	ABCD	Real	ABC
A4	ABCD	Real	ABCD
A7	ABCD	Real	bbbABCD

A-Input:

If w is greater than $4n$ (where n is the number of storage units required by the corresponding list item), the rightmost $4n$ characters are taken from the external input field. If w is less than $4n$, the w characters appear left justified with $w-4n$ trailing blanks in the internal representation.

Examples:

Format Descriptor	Input Characters	Type	Internal (b=blank)
A1	A	Integer	Ab
A3	ABC	Integer	AB
A4	ABCD	Integer	AB
A1	A	Real	Abbb
A7	ABCDEFG	Real	DEFG

H-Conversion

The forms of H conversion are as follows:

nHh1h2...hn

'h1h2...hn'

These descriptors process Hollerith character strings between the descriptor and the external field, where each h_i represents any character from the ASCII character set.

NOTE

Special consideration is required if an apostrophe (') is to be used within the literal string in the second form. An apostrophe character within the string is represented by two successive apostrophes. See the examples below.

H-Output:

The n characters h_i are placed in the external field. In the $nHh_1h_2\dots h_n$ form the number of characters in the string must be exactly as specified by n . Otherwise, characters from other descriptors will be taken as part of the string. In both forms, blanks are counted as characters.

Examples:

Format Descriptor		Output (b=blank)
1HA	or 'A'	A
8HbSTRINGb	or 'bSTRINGb'	bSTRINGb
11HX(2,3)=12.0	or 'X(2,3)=12.0'	X(2,3)=12.0
11HibSHOULDN'T	or 'IbSHOULDN'T'	IbSHOULDN'T

H-Input

The n characters of the string h_i are replaced by the next n characters from the input record. This results in a new string of characters in the field descriptor.

FORMAT Descriptor		Input (b=blank)	Resultant Descriptor
4H1234	or '1234'	ABCD	4HABCD or 'ABCD'
7HbbFALSE	or 'bbFALSE'	bFALSEb	7HbFALSEb or 'bFALSEb'
6Hbbbbbb	or 'bbbbbb'	MATRIX	6HMATRIX or 'MATRIX'

8.7.4 LOGICAL CONVERSIONS

The form of the logical conversion is as follows:

Lw

L-Output:

If the value of an item in an output list

corresponding to this descriptor is 0, an F will be output; otherwise, a T will be output. If w is greater than 1, w-1 leading blanks precede the letters.

Examples:

FORMAT Descriptor	Internal Value	Output (b=blank)
L1	=0	F
L1	<>0	T
L5	<>0	bbbbT
L7	=0	bbbbbbF

L-Input

The external representation occupies w positions. It consists of optional blanks followed by a "T" or "F", followed by optional characters.

8.7.5 X DESCRIPTOR

The form of X conversion is as follows:

nX

This descriptor causes no conversion to occur, nor does it correspond to an item in an input/output list. When used for output, it causes n blanks to be inserted in the output record. Under input circumstances, this descriptor causes the next n characters of the input record to be skipped. Note that 1X is required, as X alone will not work.

Output Examples:

FORMAT Statement	Output (b=blank)
3 FORMAT (1HA,4X,2HBC)	AbbbbBC
7 FORMAT (3X,4HABCD,1X)	bbbABCDb

Input Examples:

FORMAT Statement	Input String	Resultant Input
10 FORMAT (F4.1,3X,F3.0)	12.5ABC120	12.5,120
5 FORMAT (7X,I3)	1234567012	012

8.7.6 P DESCRIPTOR

The P descriptor is used to specify a scaling factor for real conversions (F, E, D, G). The form is nP where n is an integer constant (positive, negative, or zero).

The scaling factor is automatically set to zero at the beginning of each formatted I/O call (each READ or WRITE statement). If a P descriptor is encountered while scanning a FORMAT, the scale factor is changed to n. The scale factor remains changed until another P descriptor is encountered or the I/O terminates.

Effects of Scale Factor on Input:

During E, F, or G input the scale factor takes effect only if no exponent is present in the external representation. In that case, the internal value will be a factor of 10^{**n} less than the external value (the number will be divided by 10^{**n} before being stored).

Effect of Scale Factor on Output:

E-Output, D-Output:

The coefficient is shifted left n places relative to the decimal point, and the exponent is reduced by n (the value remains the same).

F-Output:

The external value will be 10^{**n} times the internal value.

G-Output:

The scale factor is ignored if the internal value is small enough to be output using F conversion. Otherwise, the effect is the same as for E output.

8.7.7 SPECIAL CONTROL FEATURES OF FORMAT STATEMENTS

8.7.7.1 Repeat Specifications

1. The E, F, D, G, I, L and A field descriptors may be indicated as repetitive descriptors by using a repeat count r in the form rEw.d, rFw.d, rGw.d, rIw, rLw, rAw. The following pairs of FORMAT statements are equivalent:

```
66  FORMAT (3F8.3,F9.2)
C   IS EQUIVALENT TO:
66  FORMAT (F8.3,F8.3,F8.3,F9.2)

14  FORMAT (2I3,2A5,2E10.5)
C   IS EQUIVALENT TO:
14  FORMAT (I3,I3,A5,A5,E10.5,E10.5)
```

2. Repetition of a group of field descriptors is accomplished by enclosing the group in parentheses preceded by a repeat count. Absence of a repeat count indicates a count of one. Up to two levels of parentheses, including the parentheses required by the FORMAT statement, are permitted.

Note the following equivalent statements:

```
22  FORMAT (I3,4(F6.1,2X))
C   IS EQUIVALENT TO:
22  FORMAT (I3,F6.1,2X,F6.1,2X,F6.1,2X,
1    F6.1,2X)
```

3. Repetition of FORMAT descriptors is also initiated when all descriptors in the FORMAT statement have been used but there are still items in the input/output list that have not been processed. When this occurs the FORMAT descriptors are re-used starting at the first opening parenthesis in the FORMAT statement. A repeat count preceding the parenthesized descriptor(s) to be re-used is also active in the re-use. This type of repetitive use of FORMAT descriptors terminates processing of the current record and initiates the processing of a new record each time the re-use begins. Record demarcation under these circumstances is the same as in the paragraph 8.7.7.2 below.

Input Example:

```

        DIMENSION A(100)
        READ (3,13) A
        .
        .
        .
13     FORMAT (5F7.3)

```

In this example, the first 5 quantities from each of 20 records are input and assigned to the array elements of the array A.

Output Example:

```

        .
        .
        .
        WRITE (6,12) E,F,K,L,M, KK,LL,MM,K3,L3,M3
        .
        .
        .
12     FORMAT (2F9.4,3(3I7,/))

```

In this example, three records are written. Record 1 contains E, F, K, L and M. Because the descriptor 3I7 is reused twice, Record 2 contains KK, LL and MM and Record 3 contains K3, L3 and M3.

8.7.7.2 Field Separators

Two adjacent descriptors must be separated in the FORMAT statement by either a comma or one or more slashes.

Example:

2H0K/F6.3 or 2H0K,F6.3

The slash not only separates field descriptors, but it also specifies the demarcation of formatted records.

Each slash terminates a record and sets up the next record for processing. The remainder of an input record is ignored; the remainder of an output record is filled with blanks. Successive slashes (///.../) cause successive records to be ignored on input and successive blank records to be written on output.

Output example:

```

      DIMENSION A(100),J(20)
      .
      .
      .
      WRITE (7,8) J,A
8     FORMAT (10I7/10I7/50F7.3/50F7.3)

```

In this example, the data specified by the list of the WRITE statement are output to unit 7 according to the specifications of FORMAT statement 8. Four records are written as follows:

Record 1	Record 2	Record 3	Record 4
J(1)	J(11)	A(1)	A(51)
J(2)	J(12)	A(2)	A(52)
.	.	.	.
.	.	.	.
J(10)	J(20)	A(50)	A(100)

Input Example:

```

      DIMENSION B(10)
      .
      .
      .
      READ (4,17) B
17  FORMAT(F10.2/F10.2///8F10.2)

```

In this example, the two array elements B(1) and B(2) receive their values from the first data fields of successive records (the remainders of the two records are ignored). The third and fourth records are ignored and the remaining elements of the array are filled from the fifth record.

8.7.8 FORMAT CONTROL, LIST SPECIFICATIONS AND RECORD DEMARCATION

The following relationships and interactions between FORMAT control, input/output lists and record demarcation should be noted:

1. Execution of a formatted READ or WRITE statement initiates FORMAT control.
2. The conversion performed on data depends on information jointly provided by the elements in the input/output list and field descriptors in the FORMAT statement.

3. If there is an input/output list, at least one descriptor of types E, F, D, G, I, L or A must be present in the FORMAT statement.
4. Each execution of a formatted READ statement causes a new record to be input.
5. Each item in an input list corresponds to a string of characters in the record and to a descriptor of the types E, F, G, I, L or A in the FORMAT statement.
6. H and X descriptors communicate information directly between the external record and the field descriptors without reference to list items.
7. On input, whenever a slash is encountered in the FORMAT statement or the FORMAT descriptors have been exhausted and re-use of descriptors is initiated, processing of the current record is terminated and the following occurs:
 - a. Any unprocessed characters in the record are ignored.
 - b. If more input is necessary to satisfy list requirements, the next record is read.
8. A READ statement is terminated when all items in the input list have been satisfied if:
 - a. The next FORMAT descriptor is E, F, G, I, L or A.
 - b. The FORMAT control has reached the last outer right parenthesis of the FORMAT statement.

If the input list has been satisfied, but the next FORMAT descriptor is H or X, more data are processed (with the possibility of new records being input) until one of the above conditions exists.

9. If FORMAT control reaches the last right parenthesis of the FORMAT statement but there are more list items to be processed, all or part of the descriptors are reused. (See item 3 in the description of Repeat Specifications, sub-paragraph 8.7.7.1)

10. When a Formatted WRITE statement is executed, records are written each time a slash is encountered in the FORMAT statement or FORMAT control has reached the rightmost right parenthesis. The FORMAT control terminates in one of the two methods described for READ termination in 8 above. Incomplete records are filled with blanks to maintain record lengths.

8.7.9 FORMAT CARRIAGE CONTROL

Formatted I/O to a console or printer uses the first character of each record for carriage control. The carriage control character is never printed. The carriage control character determines what action will be taken before the line is printed. The options are as follows:

<u>Control Character</u>	<u>Action Taken Before Printing</u>
0	Skip 2 lines
1	Insert Form Feed
+	No advance
Other	Skip 1 line

Formatted I/O to disk does not require the first character of each record to be a carriage control character. Records are terminated by a carriage return character (X'0D'). There are no line-feeds (X'0A') in the file unless written there explicitly.

8.7.10 FORMAT SPECIFICATIONS IN ARRAYS

The FORMAT reference, *f*, of a formatted READ or WRITE statement (See 8.1) may be an array name instead of a statement label. If such reference is made, at the time of execution of the READ/WRITE statement the first part of the information contained in the array, taken in natural order, must constitute a valid FORMAT specification. The array may contain non-FORMAT information following the right parenthesis that ends the FORMAT specification.

The FORMAT specification which is to be inserted in the array has the same form as defined for a FORMAT statement (i.e., it begins with a left parenthesis and ends with a right parenthesis).

The FORMAT specification may be inserted in the array by use of a DATA initialization statement, or

by use of a READ statement together with an Aw
FORMAT. Example:

Assume the FORMAT specification

(3F10.3,4I6)

or a similar 12 character specification is to be
stored into an array. The array must allow a
minimum of 3 storage units.

The FORTRAN coding below shows the various methods
of establishing the FORMAT specification and then
referencing the array for a formatted READ or
WRITE.

```

C  DECLARE A REAL ARRAY
      DIMENSION A(3), B(3), M(4)
C  INITIALIZE FORMAT WITH DATA STATEMENT
      DATA A/'(3F1','0.3','4I6)'/
      .
      .
      .
C  READ DATA USING FORMAT SPECIFICATIONS
C      IN ARRAY A
      READ(6,A) B, M

C  DECLARE AN INTEGER ARRAY
      DIMENSION IA(4), B(3), M(4)
      .
      .
      .
C  READ FORMAT SPECIFICATIONS
      READ (7,15) IA
C  FORMAT FOR INPUT OF FORMAT SPECIFICATIONS
15  FORMAT (4A2)
      .
      .
      .
C  READ DATA USING PREVIOUSLY INPUT
C      FORMAT SPECIFICATION
      READ (7,IA) B,M
      .
      .
      .

```


SECTION 9

FUNCTIONS AND SUBPROGRAMS

The FORTRAN language provides a means for defining and using often needed programming procedures such that the statement or statements of the procedures need appear in a program only once but may be referenced and brought into the logical execution sequence of the program whenever and as often as needed.

These procedures are as follows:

1. Statement functions.
2. Library functions.
3. FUNCTION subprograms.
4. SUBROUTINE subprograms.

Each of these procedures has its own unique requirements for reference and defining purposes. These requirements are discussed in subsequent paragraphs of this section. However, certain features are common to the whole group or to two or more of the procedures. These common features are as follows:

1. Each of these procedures is referenced by its name which, in all cases, is one to six alphanumeric characters of which the first is a letter.
2. The first three are designated as "functions" and are alike in that:
 1. They are always single valued (i.e., they return one value to the program unit from which they are referenced).
 2. They are referred to by an expression containing a function name.
 3. They must be typed by type specification statements if the data type of the single-valued result is to be different from that indicated by the pre-defined convention.
3. FUNCTION subprograms and SUBROUTINE subprograms are considered program units.

In the following descriptions of these procedures, the term calling program means the program unit or procedure in which a reference to a procedure is made, and the term "called program" means the procedure to which a reference is made.

9.1 THE PROGRAM STATEMENT

The PROGRAM statement provides a means of specifying a name for a main program unit. The form of the statement is:

PROGRAM name

If present, the PROGRAM statement must appear before any other statement in the program unit. The name consists of 1-6 alphanumeric characters, the first of which is a letter. If no PROGRAM statement is present in a main program, the compiler assigns a name of \$MAIN to that program.

9.2 STATEMENT FUNCTIONS

Statement functions are defined by a single arithmetic or logical assignment statement and are relevant only to the program unit in which they appear. The general form of a statement function is as follows:

$f(a_1, a_2, \dots, a_n) = e$

where f is the function name, the a_i are dummy arguments and e is an arithmetic or logical expression.

Rules for ordering, structure and use of statement functions are as follows:

1. Statement function definitions, if they exist in a program unit, must precede all executable statements in the unit and follow all specification statements.
2. The a_i are distinct variable names or array elements, but, being dummy variables, they may have the same names as variables of the same type appearing elsewhere in the program unit.
3. The expression e is constructed according to the rules in SECTION 4 and may contain only references to the dummy arguments and non-Literal constants, variable and array element references, utility and mathematical function references and references to previously defined statement functions.

4. The type of any statement function name or argument that differs from its pre-defined convention type must be defined by a type specification statement.
5. The relationship between f and e must conform to the replacement rules in Section 5.
6. A statement function is called by its name followed by a parenthesized list of arguments. The expression is evaluated using the arguments specified in the call, and the reference is replaced by the result.
7. The ith parameter in every argument list MUST agree in type with the ith dummy in the statement function.

The example below shows a statement function and a statement function call.

```
C  STATEMENT FUNCTION DEFINITION
C
      FUNC1(A,B,C,D) = ((A+B)**C)/D

C  STATEMENT FUNCTION CALL
C
      A12=A1-FUNC1(X,Y,Z7,C7)
```

9.3 LIBRARY FUNCTIONS

Library functions are a group of utility and mathematical functions which are "built-in" to the FORTRAN system. Their names are pre-defined to the Processor and automatically typed. The functions are listed in Tables 9-1 and 9-2. In the tables, arguments are denoted as a_1, a_2, \dots, a_n , if more than one argument is required; or as a if only one is required. A library function is called when its name is used in an arithmetic expression. Such a reference takes the following form:

$f(a_1, a_2, \dots, a_n)$

where f is the name of the function and the a_i are actual arguments. The arguments must agree in type, number and order with the specifications indicated in Tables 9-1 and 9-2.

In addition to the functions listed in 9-1 and 9-2, four additional library subprograms are provided to enable direct access to the 8080 (or Z80) hardware. These are:

PEEK, POKE, INP, OUT

For the following:

b, b1, and b2 are BYTE constants or variables
i is an INTEGER constant or variable

PEEK and INP are Logical functions; POKE and OUT are subroutines. PEEK and POKE allow direct access to any memory location. PEEK(i) returns the contents of the memory location specified by i. CALL POKE(i,b) causes the contents of the memory location specified by i to be replaced by the contents of b. INP and OUT allow direct access to the I/O ports. INP(b) does an input from port b and returns the 8-bit value input. CALL OUT(b1,b2) outputs the value of b2 to the port specified by b1.

RAN is another function in the FORTRAN library. RAN is a random number generator that is compatible with Microsoft's BASIC Compiler and BASIC-80 interpreter. The random number generated is a REAL decimal number between 0 and 1. The random number generator is called by a statement of the following form:

<variable> = RAN(x)

If x < 0, the first value of a new sequence of random numbers is returned.

If x = 0, the last random number generated is returned again.

If x > 0, the next random number in the sequence is generated.

Examples using library functions:

A1 = B+FLOAT (I7)

MAGNI = ABS(KBAR)

PDIF = DIM(C,D)

S3 = SIN(T12)

ROOT = (-B+SQRT(B**2-4.*A*C))/
1 (2.*A)

TABLE 9-1

Intrinsic Functions

Function Name	Definition	Types Argument	Function
ABS	$ a $	Real	Real
IABS		Integer	Integer
DABS		Double	Double
ASIN	Sign of a times largest integer $\leq a $	Real	Real
INT		Real	Integer
IDINT		Double	Integer
AMOD	$a1 \pmod{a2}$	Real	Real
MOD		Integer	Integer
AMAX0	$\text{Max}(a1, a2, \dots)$	Integer	Real
AMAX1		Real	Real
MAX0		Integer	Integer
MAX1		Real	Integer
DMAX1		Double	Double
AMIN0	$\text{Min}(a1, a2, \dots)$	Integer	Real
AMIN1		Real	Real
MIN0		Integer	Integer
MIN1		Real	Integer
DMIN1		Double	Double
FLOAT	Conversion from Integer to Real	Integer	Real
IFIX	Conversion from Real to Integer	Real	Integer
SIGN	Sign of a2 times $ a1 $	Real	Real
ISIGN		Integer	Integer
DSIGN		Double	Double
DIM	$a1 - \text{Min}(a1, a2)$	Real	Real
IDIM		Integer	Integer
SNGL		Double	Real
DBLE		Real	Double

TABLE 9-2

Basic External Functions

<u>Name</u>	<u>Number of Arguments</u>	<u>Type Definition</u>	<u>Argument</u>	<u>Function</u>
EXP	1	e**a	Real	Real
DEXP	1		Double	Double
ALOG	1	ln (a)	Real	Real
DLOG	1		Double	Double
ALOG10	1	log10(a)	Real	Real
DLOG10	1		Double	Double
SIN	1	sin (a)	Real	Real
DSIN	1		Double	Double
COS	1	cos (a)	Real	Real
DCOS	1		Double	Double
TANH	1	tanh (a)	Real	Real
SQRT	1	(a) ** 1/2	Real	Real
DSQRT	1		Double	Double
ATAN	1	arctan (a)	Real	Real
DATAN	1		Double	Double
ATAN2	2	arctan (a1/a2)	Real	Real
DATAN2	2		Double	Double
DMOD	2	a1(mod a2)	Double	Double

9.4 FUNCTION SUBPROGRAMS

A program unit which begins with a FUNCTION statement is called a FUNCTION subprogram.

A FUNCTION statement has one of the following forms:

t FUNCTION f(a1,a2,...an)

or

FUNCTION f(a1,a2,...an)

where:

1. t is either INTEGER, REAL, DOUBLE PRECISION or LOGICAL or is empty as shown in the second form.
2. f is the name of the FUNCTION subprogram.
3. The ai are dummy arguments of which there must be at least one and which represent variable names, array names or dummy names of SUBROUTINE or other FUNCTION subprograms.

9.5 CONSTRUCTION OF FUNCTION SUBPROGRAMS

Construction of FUNCTION subprograms must comply with the following restrictions:

1. The FUNCTION statement must be the first statement of the program unit.
2. Within the FUNCTION subprogram, the FUNCTION name must appear at least once on the left side of the equality sign of an assignment statement or as an item in the input list of an input statement. This defines the value of the FUNCTION so that it may be returned to the calling program.

Additional values may be returned to the calling program through assignment of values to dummy arguments.

Example:

```
      FUNCTION Z7(A,B,C)
      .
      .
      .
      Z7 = 5.*(A-B) + SQRT(C)
      .
      .
      .
C   REDEFINE ARGUMENT
      B=B+Z7
      .
      .
      .
      RETURN
      .
      .
      .
      END
```

3. The names in the dummy argument list may not appear in EQUIVALENCE, COMMON or DATA statements in the FUNCTION subprogram.
4. If a dummy argument is an array name, then an array declarator must appear in the subprogram with dimensioning information consistent with that in the calling program.
5. A FUNCTION subprogram may contain any defined FORTRAN statements other than BLOCK DATA statements, SUBROUTINE statements, another FUNCTION statement or any statement which references either the FUNCTION being defined or another subprogram that references the FUNCTION being defined.
6. The logical termination of a FUNCTION subprogram is a RETURN statement and there must be at least one of them.
7. A FUNCTION subprogram must physically terminate with an END statement.

Example:

```
      FUNCTION SUM (BARY,I,J)
      DIMENSION BARY(10,20)
      SUM = 0.0
      DO 8 K=1,I
      DO8 M = 1,J
8      SUM = SUM + BARY(K,M)
      RETURN
      END
```


9.6 REFERENCING A FUNCTION SUBPROGRAM

FUNCTION subprograms are called whenever the FUNCTION name, accompanied by an argument list, is used as an operand in an expression. Such references take the following form:

`f(a1,a2,...,an)`

where `f` is a FUNCTION name and the `ai` are actual arguments. Parentheses must be present in the form shown.

The arguments `ai` MUST agree in type, order and number with the dummy arguments in the FUNCTION statement of the called FUNCTION subprogram. There is no type conversion of arguments. There must be at least one argument. Arguments may be any of the following:

1. A variable name.
2. An array element name.
3. An array name.
4. An expression.
5. A SUBROUTINE or FUNCTION subprogram name.
6. A Hollerith or Literal constant.

If an `ai` is a subprogram name, that name must have previously been distinguished from ordinary variables by appearing in an EXTERNAL statement and the corresponding dummy arguments in the called FUNCTION subprograms must be used in subprogram references.

If `ai` is a Hollerith or Literal constant, the corresponding dummy variable should encompass enough storage units to correspond exactly to the amount of storage needed by the constant.

When a FUNCTION subprogram is called, program control goes to the first executable statement following the FUNCTION statement.

The following examples show references to FUNCTION subprograms.

```
      Z10 = FT1+Z7(D,T3,RHO)

      DIMENSION DAT(5,5)
      .
      .
      .
      S1 = TOT1 + SUM(DAT,5,5)
```

9.7 SUBROUTINE SUBPROGRAMS

A program unit which begins with a SUBROUTINE statement is called a SUBROUTINE subprogram. The SUBROUTINE statement has one of the following forms:

```
SUBROUTINE s (a1,a2,...,an)
```

or

```
SUBROUTINE s
```

where s is the name of the SUBROUTINE subprogram and each ai is a dummy argument which represents a variable or array name or another SUBROUTINE or FUNCTION name.

9.8 CONSTRUCTION OF SUBROUTINE SUBPROGRAMS

1. The SUBROUTINE statement must be the first statement of the subprogram.
2. The SUBROUTINE subprogram name must not appear in any statement other than the initial SUBROUTINE statement.
3. The dummy argument names must not appear in EQUIVALENCE, COMMON or DATA statements in the subprogram.
4. If a dummy argument is an array name then an array declarator must appear in the subprogram with dimensioning information consistent with that in the calling program.
5. If any of the dummy arguments represent values that are to be determined by the SUBROUTINE subprogram and returned to the calling program, these dummy arguments must appear within the subprogram on the left side of the equality sign in a replacement statement, in the input list of an input statement or as a parameter within a subprogram reference.

6. A SUBROUTINE may contain any FORTRAN statements other than BLOCK DATA statements, FUNCTION statements, another SUBROUTINE statement, a PROGRAM statement or any statement which references the SUBROUTINE subprogram being defined or another subprogram which references the SUBROUTINE subprogram being defined.
7. A SUBROUTINE subprogram may contain any number of RETURN statements. It must have at least one.
8. The RETURN statement(s) is the logical termination point of the subprogram.
9. The physical termination of a SUBROUTINE subprogram is an END statement.
10. If an actual argument transmitted to a SUBROUTINE subprogram by the calling program is the name of a SUBROUTINE or FUNCTION subprogram, the corresponding dummy argument must be used in the called SUBROUTINE subprogram as a subprogram reference.

Example:

```
C SUBROUTINE TO COUNT POSITIVE ELEMENTS
C      IN AN ARRAY
      SUBROUTINE COUNT P(ARRY,I,CNT)
      DIMENSION ARRY(7)
      CNT = 0
      DO 9 J=1,I
      IF(ARRY(J))9,5,5
9      CONTINUE
      RETURN
5      CNT = CNT+1.0
      GO TO 9
      END
```

9.9 REFERENCING A SUBROUTINE SUBPROGRAM

A SUBROUTINE subprogram may be called by using a CALL statement. A CALL statement has one of the following forms:

```
CALL s(a1,a2,...,an)
```

or

```
CALL s
```

where s is a SUBROUTINE subprogram name and the ai are the actual arguments to be used by the subprogram. The ai must agree in type, order and number with the corresponding dummy arguments in the subprogram-defining SUBROUTINE statement.

The arguments in a CALL statement must comply with the following rules:

1. FUNCTION and SUBROUTINE names appearing in the argument list must have previously appeared in an EXTERNAL statement.
2. If the called SUBROUTINE subprogram contains a variable array declarator, then the CALL statement must contain the actual name of the array and the actual dimension specifications as arguments.
3. If an item in the SUBROUTINE subprogram dummy argument list is an array, the corresponding item in the CALL statement argument list must be an array.

When a SUBROUTINE subprogram is called, program control goes to the first executable statement following the SUBROUTINE statement.

Example:

```
        DIMENSION DATA(10)
        .
        .
        .
C   THE STATEMENT BELOW CALLS THE
C       SUBROUTINE IN THE PREVIOUS PARAGRAPH
C
        CALL COUNTP(DATA,10,CPOS)
```

9.10 RETURN FROM FUNCTION AND SUBROUTINE SUBPROGRAMS

The logical termination of a FUNCTION or SUBROUTINE subprogram is a RETURN statement which transfers control back to the calling program. The general form of the RETURN statement is simply the word

RETURN

The following rules govern the use of the RETURN statement:

1. There must be at least one RETURN statement in each SUBROUTINE or FUNCTION subprogram.
2. RETURN from a FUNCTION subprogram is to the instruction sequence of the calling program following the FUNCTION reference.
3. RETURN from a SUBROUTINE subprogram is to the next executable statement in the calling program which would logically follow the CALL statement.
4. Upon return from a FUNCTION subprogram the single-valued result of the subprogram is available to the evaluation of the expression from which the FUNCTION call was made.
5. Upon return from a SUBROUTINE subprogram the values assigned to the arguments in the SUBROUTINE are available for use by the calling program.

Example:

Calling Program Unit

```
.  
.   
.   
    CALL SUBR(Z9,B7,R1)  
.   
.   
.
```

Called Program Unit

```
    SUBROUTINE SUBR(A,B,C)  
    READ(3,7) B  
    A = B**C  
    RETURN  
7   FORMAT(F9.2)  
    END
```

In this example, Z9 and B7 are made available to the calling program when the RETURN occurs.

9.11 PROCESSING ARRAYS IN SUBPROGRAMS

If a calling program passes an array name to a subprogram, the subprogram must contain the dimension information pertinent to the array. A subprogram must contain array declarators if any of its dummy arguments represent arrays or array elements.

For example, a FUNCTION subprogram designed to compute the average of the elements of any one dimension array might be the following:

Calling Program Unit

```
DIMENSION Z1(50),Z2(25)
.
.
.
A1 = AVG(Z1,50)
.
.
.
A2 = A1-AVG(Z2,25)
.
.
.
```

Called Program Unit

```
FUNCTION AVG(ARG,I)
DIMENSION ARG(50)
SUM = 0.0
DO 20 J=1,I
20  SUM = SUM + ARG(J)
AVG = SUM/FLOAT(I)
RETURN
END
```

Note that actual arrays to be processed by the FUNCTION subprogram are dimensioned in the calling program and the array names and their actual dimensions are transmitted to the FUNCTION subprogram by the FUNCTION subprogram reference. The FUNCTION subprogram itself contains a dummy array and specifies an array declarator.

Dimensioning information may also be passed to the subprogram in the parameter list. For example:

Calling Program Unit

```
DIMENSION A(3,4,5)
.
.
.
CALL SUBR(A,3,4,5)
.
.
.
END
```

Called Program Unit

```
SUBROUTINE SUBR(X,I,J,K)
DIMENSION X(I,J,K)
.
.
.
RETURN
END
```

It is valid to use variable dimensions only when the array name and all of the variable dimensions are dummy arguments. The variable dimensions must be type Integer. It is invalid to change the values of any of the variable dimensions within the called program.

9.12 BLOCK DATA SUBPROGRAMS

A BLOCK DATA subprogram has as its only purpose the initialization of data in a COMMON block during loading of a FORTRAN object program. BLOCK DATA subprograms begin with a BLOCK DATA statement of the following form:

BLOCK DATA [subprogram-name]

and end with an END statement. Such subprograms may contain only Type, EQUIVALENCE, DATA, COMMON and DIMENSION statements and are subject to the following considerations:

1. If any element in a COMMON block is to be initialized, all elements of the block must be listed in the COMMON statement even though they might not all be initialized.
2. Initialization of data in more than one COMMON block may be accomplished in one BLOCK DATA subprogram.
3. There may be more than one BLOCK DATA subprogram loaded at any given time.
4. Any particular COMMON block item should only be initialized by one program unit.

Example:

```
BLOCK DATA
LOGICAL A1
COMMON/BETA/B(3,3)/GAM/C(4)
COMMON/ALPHA/A1,F,E,D
DATA B/1.1,2.5,3.8,3*4.96,
12*0.52,1.1/,C/1.2E0,3*4.0/
DATA A1/.TRUE./,E/-5.6/
```


9.13 PROGRAM CHAINING

Programs may be loaded and executed (CHAINED) by a FORTRAN program through the CALL FCHAIN facility. The general syntax is:

```
CALL FCHAIN ('filename')
```

where filename is a valid operating-system-dependent file specification of a machine executable file. The exact syntax varies under different operating systems. Refer to the "Microsoft FORTRAN-80 User's Manual", Section 3.

RULES:

1. 'filename' must be valid according to your operating system's rules.
2. The program CHAINED must be a "MAIN" program. That is, one having an ENTRY Point. FORTRAN, COBOL, and assembly language subroutines do not contain a "MAIN" entry point.
3. Parameters may not be passed to CHAINED programs.
4. Illegal filename, Illegal drive specification, File not found, Out of memory, and Disk read errors will result in a fatal **IO** Error.

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APPENDIX A

Language Extensions and Restrictions

The FORTRAN-80 language includes the following extensions to ANSI Standard FORTRAN (X3.9-1966).

1. If `c` is used in a `'STOP c'` or `'PAUSE c'` statement, `c` may be any six ASCII characters.
2. Error and End-of-File branches may be specified in `READ` and `WRITE` statements using the `ERR=` and `END=` options.
3. The standard subprograms `PEEK`, `POKE`, `INP`, and `OUT` have been added to the FORTRAN library.
4. Statement functions may use subscripted variables.
5. Hexadecimal constants may be used wherever Integer constants are normally allowed.
6. The literal form of Hollerith data (character string between apostrophe characters) is permitted in place of the standard `nH` form.
7. Holleriths and Literals are allowed in expressions in place of Integer constants.
8. There is no restriction to the number of continuation lines.
9. Mixed mode expressions and assignments are allowed, and conversions are done automatically.

FORTRAN-80 places the following restrictions upon Standard FORTRAN.

1. The COMPLEX data type is not implemented.
2. The specification statements must appear in the following order:
 1. PROGRAM, SUBROUTINE, FUNCTION, BLOCK DATA
 2. Type, EXTERNAL, DIMENSION
 3. COMMON
 4. EQUIVALENCE
 5. DATA
 6. Statement Functions
3. A different amount of computer memory is allocated for each of the data types: Integer, Real, Double Precision, Logical.
4. The equal sign of a replacement statement and the first comma of a DO statement must appear on the initial statement line.
5. In Input/Output list specifications, sublists enclosed in parentheses are not allowed.

Descriptions of these language extensions and restrictions are included at the appropriate points in the text of this document.

APPENDIX B

I/O Interface

Input/Output operations are table-dispatched to the driver routine for the proper Logical Unit Number. \$LUNTB is the dispatch table. It contains one 2-byte driver address for each possible LUN. It also has a one-byte entry at the beginning, which contains the maximum LUN plus one.

The initial run-time package provides for 10 LUN's (1 - 10). Units 1, 3, 4, and 5 are preassigned to the console (TTY). Unit 2 is preassigned to the Line Printer. Units 6-10 are preassigned to Disk Files (see User's Manual, Section 3).

Any of these may be redefined by the user simply by changing the appropriate entries in \$LUNTB. The runtime system uses LUN 3 for errors and other user communication. Therefore, LUN 3 should correspond to the operator console. The initial structure of \$LUNTB is shown in the listings following this appendix.

It is also possible to add LUNs to \$LUNTB. If you do this, change the MAXLUN+1 byte at the label \$LUNTB, and make sure you also change the value of MAXLUN in the DSKDRV.MAC module.

The device drivers also contain local dispatch tables. Note that \$LUNTB contains one address for each device, yet there are really seven possible operations per device:

- 1) Formatted Read
- 2) Formatted Write
- 3) Unformatted Read
- 4) Unformatted Write
- 5) Rewind
- 6) Backspace
- 7) Endfile

Each device driver contains up to seven routines. The starting addresses of each of these seven routines are placed at the beginning of the driver, in the exact order listed above. The entry in \$LUNTB then points to this local table, and the runtime system indexes into it to get the address of the appropriate routine to handle the requested I/O operation.

The following conventions apply to the individual I/O routines:

1. Location \$BF contains the data buffer address for READs and WRITEs.
2. For a WRITE, the number of bytes to write is in location \$BL.
3. For a READ, the number of bytes read should be returned in \$BL.
4. All I/O operations set the condition codes before exit to indicate an error condition, end-of-file condition, or normal return:
 - a) CY=1, Z=don't care - I/O error
 - b) CY=0, Z=0 - end-of-file encountered
 - c) CY=0, Z=1 - normal return

The runtime system checks the condition codes after calling the driver. If they indicate a non-normal condition, control is passed to the label specified by "ERR=" or "END=" or, if no label is specified, a fatal error results.

5. \$IOERR is a global routine which prints an "ILLEGAL I/O OPERATION" message (non-fatal). This routine may be used if there are some operations not allowed on a particular device (i.e. Unformatted I/O on a TTY).

NOTE

The I/O buffer has a fixed maximum length of 132 bytes. If a driver allows an input operation to write past the end of the buffer, essential runtime variables may be affected. The consequences are unpredictable.

The listings following this appendix contain an example driver for a TTY. REWIND, BACKSPACE, and ENDFILE are implemented as No-Ops and Unformatted I/O as an error. This is the TTY driver provided with the runtime package.

```

00100 ; TTY I/O DRIVER
00200
00300 EXT SIOERR,$BL,$BF,$ERR,$TTYIN,$TTYOT
00400 IRECER EQU 022 ;INPUT RECORD TOO LONG
00500 ENTRY $DRV3
00600 $DRV3: DW DRV3FR ;FORMATTED READ
00700 DW DRV3FW ;FORMATTED WRITE
00800 DW DRV3BR ;BINARY READ
00900 DW DRV3BW ;BINARY WRITE
01000 DW DRV3RE ;REWIND
01100 DW DRV3BA ;BACKSPACE
01200 DW DRV3EN ;ENDFILE
01300 DRV3EN: XRA A ;THESE OPERATIONS ARE
01400 ;NO-OPS FOR TTY
01500 DRV3RE EQU DRV3EN
01600 DRV3BA EQU DRV3EN
01700 RET
01800 DRV3BW: JMP SIOERR ;ILLEGAL OPERATIONS
01900 ;(PRINT ERROR AND RETURN)
02000 DRV3BR EQU DRV3BW
02100 DRV3FR: XRA A ;READ
02200 STA $BL ;ZERO BUFFER LENGTH
02300 DRV31: CALL $TTYIN ;INPUT A CHAR
02400 ANI 0177 ;AND OFF PARITY
02500 CPI 10 ;IGNORE LINE FEEDS
02600 JZ DRV31
02700 PUSH PSW ;SAVE IT
02800 LHL $BL ;GET CHAR POSIT IN BUFFER
02900 MVI H,0 ;ONLY 1 BYTE
03000 XCHG
03100 LHL $BF ;GET BUFFER ADDR
03200 DAD D ;ADD OFFSET
03300 POP PSW ;GET CHAR
03400 MOV M,A ;PUT IT IN BUFFER
03500 INX D ;INCREMENT $BL
03600 XCHG
03700 SHLD $BL ;SAVE IT
03800 CPI 015 ;CR?
03900 RZ ;YES—DONE
04000 MOV A,L ;$BL
04100 CPI 128 ;MAX IS DECIMAL 128
04200 JC DRV31 ;GET NEXT CHAR
04300 CALL $ERR
04400 DB IRECER ;INPUT RECORD TOO LONG
04500 XRA A ;CLEAR FLAGS
04600 RET
04700 DRV3FW: LDA $BL ;BUFFER LENGTH
04800 ORA A

```

0046	C8	04900	RZ		;EMPTY BUFFER
0047	2A 0029 *	05000	LHLD	\$BF	;BUFFER ADDRESS
004A	3D	05100	DCR	A	;DECREMENT LENGTH
004B	F5	05200	PUSH	PSW	;SAVE IT
004C	3E 0D	05300	MVI	A,13	;CR
004E	CD 0000 *	05400	CALL	\$TTYOT	;OUTPUT IT
0051	7E	05500	MOV	A,M	;GET FIRST CHAR IN BUFFER
0052	FE 2B	05600	CPI	'1'	
0054	CA 0079 '	05700	JZ	DRV3FW2	;NO LINE FEEDS
0057	FE 31	05800	CPI	'1'	
0059	C2 0064 '	05900	JNZ	DRV3FW1	;NOT FORM FEED
005C	3E 0C	06000	MVI	A,12	;FORM FEED
005E	CD 004F *	06100	CALL	\$TTYOT	;OUTPUT IT
0061	C3 0079 '	06200	JMP	DRV3FW2	
0064	3E 0A	06300	DR3FW1: MVI	A,10	;LF
0066	CD 005F *	06400	CALL	\$TTYOT	
0069	7E	06500	MOV	A,M	;GET CHAR BACK
006A	FE 20	06600	CPI	'1'	
006C	CA 0079 '	06700	JZ	DRV3FW2	;NO MORE LINE FEEDS
006F	FE 30	06800	CPI	'0'	
0071	C2 0079 '	06900	JNZ	DRV3FW2	;NO MORE LINE FEEDS
0074	3E 0A	07000	MVI	A,10	;LF
0076	CD 0067 *	07100	CALL	\$TTYOT	
0079	F1	07200	DR3FW2: POP	PSW	;GET LENGTH BACK
007A	23	07300	INX	H	;INCREMENT PTR
007B	C8	07400	DRV32: RZ		
007C	F5	07500	PUSH	PSW	;SAVE CHAR COUNT
007D	7E	07600	MOV	A,M	;GET NEXT CHAR
007E	23	07700	INX	H	;INCREMENT PTR
007F	CD 0077 *	07800	CALL	\$TTYOT	;OUTPUT CHAR
0082	F1	07900	POP	PSW	;GET COUNT
0083	3D	08000	DCR	A	;DECREMENT IT
0084	C3 007B '	08100	JMP	DRV32	;ONE MORE TIME
0087		08200	END		

\$IOERR	0011*	\$BL	0043*	\$BF	0048*	\$ERR	003D*
\$TTYIN	0018*	\$TTYOT	0080*	IRECER	0012	\$DRV3	0000'
DRV3FR	0013'	DRV3FW	0042'	DRV3BR	0010'	DRV3BW	0010'
DRV3RE	000E'	DRV3BA	000E'	DRV3EN	000E'	DRV31	0017'
DRV3W2	0079'	DRV3W1	0064'	DRV32	007B'		


```

00100 ;COMMENT *
00200 ; DRIVER ADDRESSES FOR LUN'S 1 THROUGH 10
00210 ;
0001 00220 LPT EQU 1 ;UNIT 2 IS LPT
0001 00230 DSK EQU 1 ;UNITS 6-10 ARE DSK
0000 00235 DTC EQU 0 ;DTC COMMUNICATIONS UNIT 4
00240 ;
00300
0000 00400 ENTRY $LUNTB
0000 00500 EXT $DRV3
0000 00600 $LUNTB: DB 013 ;MAX LUN + 1
0001 00700 DW $DRV3 ;THEY ALL POINT TO $DRV3 FOR NOW
0003 00800 IFF LPT
00900 DW $DRV3
01000
0003 01100 ENDF
0003 01200 IFT LPT
0003 01300 EXT LPTDRV
0003 01400 DW LPTDRV
0005 01500 ENDF
0005 01600 DW $DRV3
0007 01700 IFF DTC
0007 01800 DW $DRV3
0009 01900 ENDF
0009 02000 IFT DTC
0009 02100 EXT $CMDRV
0009 02200 DW $CMDRV
0009 02300 ENDF
0009 02400 DW $DRV3
0009 02500 IFF DSK
0009 02600 DW $DRV3
0009 02700 DW $DRV3
0009 02800 DW $DRV3
0009 02900 DW $DRV3
0009 03000 DW $DRV3
0009 03100 ENDF
0009 03200 END
0009 03300

```

```

LPT 0001 DSK 0001 DTC 0000 $LUNTB 0000'
$DRV3 0009* LPTDRV 0003* DSKDRV 0013*

```

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APPENDIX C

Subprogram Linkages

This appendix defines a normal subprogram call as generated by the FORTRAN compiler. It is included to facilitate linkages between FORTRAN programs and those written in other languages, such as 8080 Assembly.

A subprogram reference with no parameters generates a simple "CALL" instruction. The corresponding subprogram should return via a simple "RET." (CALL and RET are 8080 opcodes - see the assembly manual or 8080 reference manual for explanations.)

A subprogram reference with parameters results in a somewhat more complex calling sequence. Parameters are always passed by reference (i.e., the thing passed is actually the address of the low byte of the actual argument). Therefore, parameters always occupy two bytes each, regardless of type.

The method of passing the parameters depends upon the number of parameters to pass:

1. If the number of parameters is less than or equal to 3, they are passed in the registers. Parameter 1 will be in HL, 2 in DE (if present), and 3 in BC (if present).
2. If the number of parameters is greater than 3, they are passed as follows:
 1. Parameter 1 in HL.
 2. Parameter 2 in DE.
 3. Parameters 3 through n in a contiguous data block. BC will point to the low byte of this data block (i.e., to the low byte of parameter 3).

Note that, with this scheme, the subprogram must know how many parameters to expect in order to find them. Conversely, the calling program is responsible for passing the correct number of parameters. Neither the compiler nor the runtime system checks for the correct number of parameters.

If the subprogram expects more than 3 parameters, and needs to transfer them to a local data area, there is a system subroutine which will perform this transfer. This argument

transfer routine is named \$AT, and is called with HL pointing to the local data area, BC pointing to the third parameter, and A containing the number of arguments to transfer (i.e., the total number of arguments minus 2). The subprogram is responsible for saving the first two parameters before calling \$AT. For example, if a subprogram expects 5 parameters, it should look like:

```

SUBR:  SHLD    P1            ;SAVE PARAMETER 1
       XCHG
       SHLD    P2            ;SAVE PARAMETER 2
       MVI     A,3           ;NO. OF PARAMETERS LEFT
       LXI     H,P3          ;POINTER TO LOCAL AREA
       CALL    $AT          ;TRANSFER THE OTHER 3 PARAMETERS
       .
       .
       [Body of subprogram]
       .
       .
       RET                ;RETURN TO CALLER
P1:    DS      2            ;SPACE FOR PARAMETER 1
P2:    DS      2            ;SPACE FOR PARAMETER 2
P3:    DS      6            ;SPACE FOR PARAMETERS 3-5

```

When accessing parameters in a subprogram, don't forget that they are pointers to the actual arguments passed.

NOTE

It is entirely up to the programmer to see to it that the arguments in the calling program match in number, type, and length with the parameters expected by the subprogram. This applies to FORTRAN subprograms, as well as those written in assembly language.

FORTRAN Functions (Section 9) return their values in registers or memory depending upon the type. Logical results are returned in (A), Integers in (HL). Extended integers and Reals return results in memory at \$AC. Double Precision Reals return results in memory at \$DAC. \$AC and \$DAC are the addresses of the low bytes of the mantissas.

APPENDIX D

ASCII CHARACTER CODES

DECIMAL	CHAR.	DECIMAL	CHAR.	DECIMAL	CHAR.
000	NUL	043	+	086	V
001	SOH	044	,	087	W
002	STX	045	-	088	X
003	ETX	046	.	089	Y
004	EOT	047	/	090	Z
005	ENQ	048	0	091	[
006	ACK	049	1	092	\
007	BEL	050	2	093]
008	BS	051	3	094	^
009	HT	052	4	095	~
010	LF	053	5	096	
011	VT	054	6	097	a
012	FF	055	7	098	b
013	CR	056	8	099	c
014	SO	057	9	100	d
015	SI	058	:	101	e
016	DLE	059	;	102	f
017	DC1	060	<	103	g
018	DC2	061	=	104	h
019	DC3	062	>	105	i
020	DC4	063	?	106	j
021	NAK	064	@	107	k
022	SYN	065	A	108	l
023	ETB	066	B	109	m
024	CAN	067	C	110	n
025	EM	068	D	111	o
026	SUB	069	E	112	p
027	ESCAPE	070	F	113	q
028	FS	071	G	114	r
029	GS	072	H	115	s
030	RS	073	I	116	t
031	US	074	J	117	u
032	SPACE	075	K	118	v
033	!	076	L	119	w
034	"	077	M	120	x
035	#	078	N	121	y
036	\$	079	O	122	z
037	%	080	P	123	{
038	&	081	Q	124	
039	'	082	R	125	}
040	(083	S	126	~
041)	084	T	127	DEL
042	*	085	U		

LF=Line Feed FF=Form Feed CR=Carriage Return DEL=Rubout

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APPENDIX E

Referencing FORTRAN-80 Library Subroutines

The FORTRAN-80 library contains a number of subroutines that may be referenced by the user from FORTRAN or assembly programs.

1. Referencing Arithmetic Routines

In the following descriptions, \$AC refers to the floating accumulator; \$AC is the address of the low byte of the mantissa. \$AC+3 is the address of the exponent. \$DAC refers to the DOUBLE PRECISION accumulator; \$DAC is the address of the low byte of the mantissa. \$DAC+7 is the address of the DOUBLE PRECISION exponent.

All arithmetic routines (addition, subtraction, multiplication, division, exponentiation) adhere to the following calling conventions.

1. Argument 1 is passed in the registers:
Integer in [HL]
Real in \$AC
Double in \$DAC
2. Argument 2 is passed either in registers, or in memory depending upon the type:
 - a. Integers are passed in [HL], or [DE] if [HL] contains Argument 1.
 - b. Real and Double Precision values are passed in memory pointed to by [HL]. ([HL] points to the low byte of the mantissa.)

The following arithmetic routines are contained in the Library:

<u>Function</u>	<u>Name</u>	<u>Argument 1 Type</u>	<u>Argument 2 Type</u>
Addition	\$AY	Integer*4	Integer
	\$Al	Integer*4	Integer*4
	\$AA	Real	Integer
	\$AE	Real	Integer*4
	\$AB	Real	Real
	\$AQ	Double	Integer
	\$AV	Double	Integer*4
	\$AR	Double	Real
	\$AU	Double	Double
Division	\$D9	Integer	Integer
	\$DY	Integer*4	Integer
	\$Dl	Integer*4	Integer*4
	\$DA	Real	Integer
	\$DE	Real	Integer*4
	\$DB	Real	Real
	\$DQ	Double	Integer
	\$DV	Double	Integer*4
	\$DR	Double	Real
	\$DU	Double	Double
Exponentiation	\$E9	Integer	Integer
	\$EY	Integer*4	Integer
	\$El	Integer*4	Integer*4
	\$EA	Real	Integer
	\$EE	Real	Integer*4
	\$EB	Real	Real
	\$EQ	Double	Integer
	\$EV	Double	Integer*4
	\$ER	Double	Real
	\$EU	Double	Double
Multiplication	\$M9	Integer	Integer
	\$MY	Integer*4	Integer
	\$Ml	Integer*4	Integer*4
	\$MA	Real	Integer
	\$ME	Real	Integer*4
	\$MB	Real	Real
	\$MQ	Double	Integer
	\$MV	Double	Integer*4
	\$MR	Double	Real
	\$MU	Double	Double
Subtraction	\$SY	Integer*4	Integer
	\$Sl	Integer*4	Integer*4
	\$SA	Real	Integer
	\$SE	Real	Integer*4
	\$SB	Real	Real
	\$SQ	Double	Integer
	\$SV	Double	Integer*4
	\$SR	Double	Real
	\$SU	Double	Double

Additional Library routines are provided for converting between value types. Arguments are always passed to and returned by these conversion routines in the appropriate registers:

Logical in [A]

Integer in [HL]

Extended Integer in \$AC

Real in \$AC

Double Precision REAL in \$DAC

<u>Name</u>	<u>Function</u>
\$CD	Integer to Integer*4
\$CA	Integer to Real
\$CC	Integer to Double
\$C4	Integer*4 to Integer
\$C5	Integer*4 to Real
\$C6	Integer*4 to Logical
\$C7	Integer*4 to Double
\$CH	Real to Integer
\$CL	Real to Integer*4
\$CJ	Real to Logical
\$CK	Real to Double
\$CX	Double to Integer
\$C0	Double to Integer*4
\$CY	Double to Real
\$CZ	Double to Logical

2. Referencing Intrinsic Functions

Intrinsic Functions are passed their parameters in H,L and D,E. If there are three arguments, B,C contains the third parameter. If there are more than three arguments, B,C contains a pointer to a block in memory that holds the remaining parameters. Each of these parameters is a pointer to an argument. (See Appendix B.)

For a MIN or MAX function, the number of arguments is passed in A.

NOTE

None of the functions (except INP and OUT) may take a byte variable as an argument. Byte variables must first be converted to the type expected by the function. Otherwise, results will be unpredictable.

3. Formatted READ and WRITE Routines

A READ or WRITE statement calls one of the following routines:

\$W2 (2 parameters)	Initialize for an I/O transfer
\$W5 (5 parameters)	to a device (WRITE)
\$R2 (2 parameters)	Initialize for an I/O transfer
\$R5 (5 parameters)	from a device (READ)

These routines adhere to the following calling conventions:

1. H,L points to the LUN
2. D,E points to the beginning of the FORMAT statement
3. If the routine has five parameters, then B,C points to a block of three parameters:
 - a. the address for an ERR= branch
 - b. the address for an EOF= branch
 - c. the address for a REC= value

The routines that transfer values into the I/O buffer are:

\$I0	transfers integers
\$I1	transfers real numbers
\$I2	transfers logicals
\$I3	transfers double precision numbers
\$I4	transfers extended integers (4 bytes)

Transfer routines adhere to the following calling conventions:

1. H,L points to a location that contains the number of dimensions for the variables in the list
2. D,E points to the first value to be transferred
3. B,C points to the second value to be transferred if there are exactly two values to be transferred by this call. If there are more than two values, B,C points to a block that contains pointers to the second through nth values.
4. Register A contains the number of parameters (including H,L) generated by this call.

The routine \$ND terminates the I/O process.

Example:

```

                EXTRN    $W2,$IO,$ND
                ENTRY    TEST
TEST:          LXI      H,LUN
                LXI      D,FORMAT
                CALL     $W2

                LXI      H,DIMENS
                LXI      D,NUMBER
                MVI      A,2
                CALL     $IO

                CALL     $ND

                RET
LUN:           DW       1
FORMAT:        DB       '(11H RESULT IS=,15)'
DIMENS:        DW       1
NUMBER:        DW       9999

                END      TEST
```

4. Loading and Storing Floating Accumulator

In the following definitions, \$AC refers to the floating accumulator and \$DAC refers to the DOUBLE PRECISION accumulator.

To Load Floating Accumulator:

(H,L points to value to be loaded.)

<u>Name</u>	<u>Function</u>
\$L1	Loads into \$AC, 4 bytes
\$L3	Loads into \$DAC, 8 bytes

To Store Floating Accumulator:

(H,L points to memory where value is to be stored)

<u>Name</u>	<u>Function</u>
\$T1	Stores 4 bytes from \$AC
\$T3	Stores 8 bytes from \$DAC

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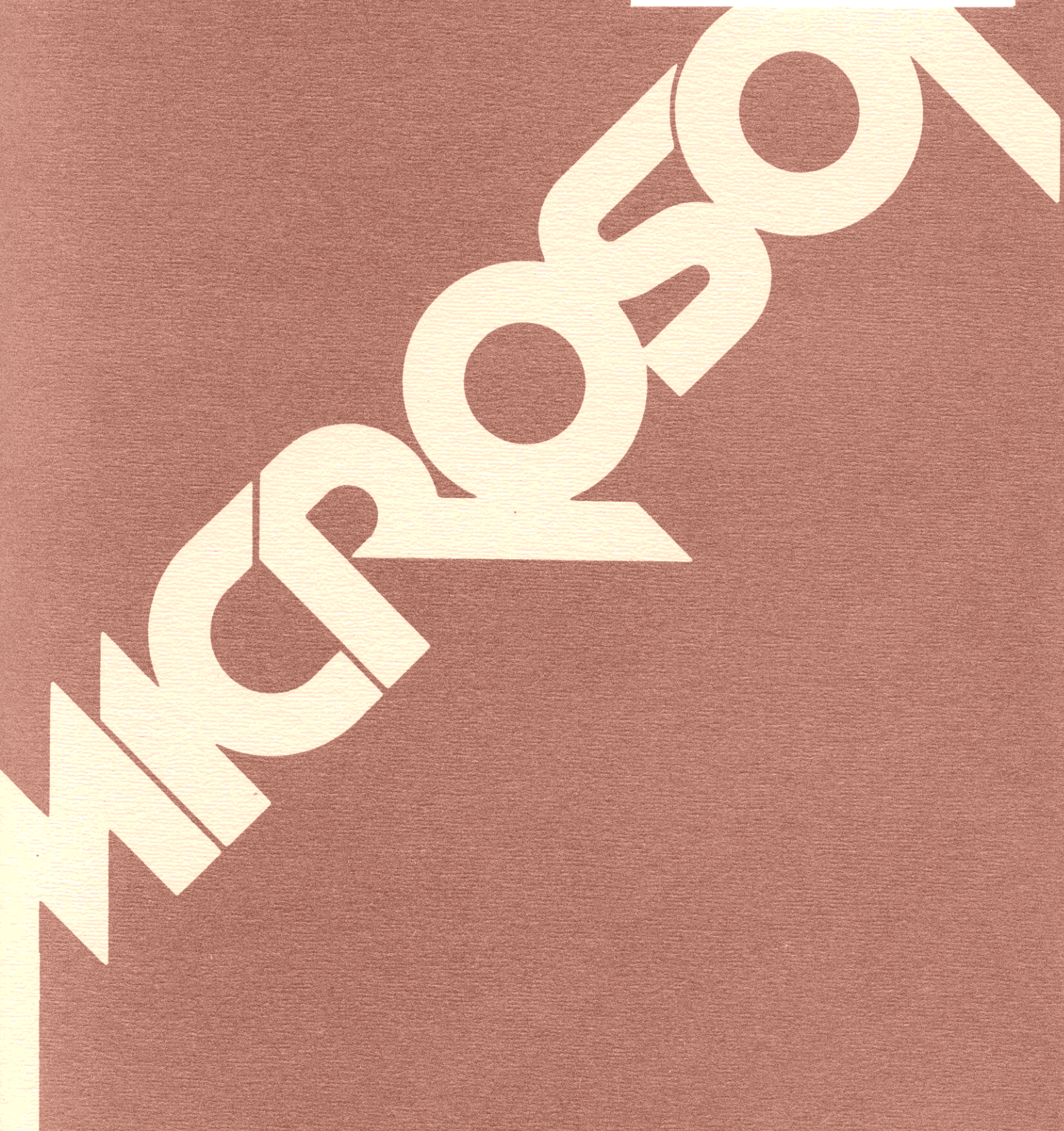
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edit-80
user's guide



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Microsoft EDIT-80
for the Radio Shack TRS-80
Model I Computer

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edit-80 user's guide

Microsoft EDIT-80
for the Radio Shack TRS-80
Model I Computer

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Addendum to: EDIT-80 User's Guide
For TRS-80 Model I

Add to Section 1.2, Running EDIT-80:

Upon entering EDIT-80, the filename is requested by the prompt

FILE:

If the <break> key is typed at this point (instead of a filename), EDIT-80 will exit to the operating system.

Add to Section 2.4, Print Command:

Typing P <enter> causes the next 10 lines to be displayed, instead of the next 20 lines.

Add to Sections 6.1 and 6.3, Exit and Write Commands:

When Exiting or Writing a file, a filename is always required, unless it is the first time the file is being written to disk. However, it is not necessary to include a drive number with the filename. The file will be written to the drive from which it was obtained, if no drive number is specified.

Add to Appendix D, EDIT-80 Special Characters:

1. If the up-arrow key or the <break> key is typed at command level, the previous line is displayed.
2. If the down-arrow key (line feed) is typed at command level, the next line is displayed.
3. The right-arrow key (tab) inserts a true tab into the line of text. (Previous versions of EDIT-80 inserted the number of spaces displayed on the screen.)
4. The shift-@ key has the effect of Control-S. Shift-@ halts and resumes execution of an EDIT-80 command.

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Microsoft EDIT-80 User's Guide

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CHAPTER 1

EDIT-80 Operation

1.1 Introduction

EDIT-80 is a line-oriented and character-oriented text editor. EDIT-80 commands are simple and straightforward, yet powerful enough to accommodate the most demanding user. For the novice or for those requiring only cursory use of EDIT-80, the first four chapters of this document contain all the information necessary to complete a fairly extensive editing session. The remaining chapters describe the enhancements to EDIT-80 that provide the user with more sophisticated techniques.

1.2 Running EDIT-80

To run EDIT-80, type and enter

EDIT

at TRSDOS command level. EDIT-80 will ask for the filename by typing

FILE:

Enter the name of your file. Use TRSDOS filename format for the filename:

filename[/extension][.password][:drive#]

If the filename refers to a file that already exists, type the filename followed by <enter>, and EDIT-80 will read in the file. If the file does not have line numbers, EDIT-80 will append them, beginning with line number 100 and incrementing by 100. After EDIT-80 prints

Version x.x

Copyright 1977,78 (c) by Microsoft

Created: xxxx

xxxx Bytes free

*

-

it is at command level, as indicated by the * prompt. All commands to EDIT-80 are entered after the * prompt.

If the filename refers to a new file to be created, type the filename followed by the <break> key.

EDIT-80 will return the message

```
Creating  
Version x.x  
Copyright 1977,78 (c) by Microsoft  
Created: xxxx  
xxxx Bytes free  
*  
—
```

Next enter the command I (see Section 2.1 for a further description of the I command). EDIT-80 will type the first line number, 00100, followed by a tab.

```
*I  
00100
```

Now you are ready to enter the first line of your file. A line consists of up to 255 characters and is terminated by <enter>. After every line entered, EDIT-80 will type the next line number, incrementing by 100. This is the "permanent increment." (There are various commands that will change the permanent increment - see Chapter 2.) Line numbers 00000 through 99999 are available for use in your EDIT-80 file.

NOTE

Microsoft products such as TRS-80 FORTRAN and MACRO-80 all support input files which include EDIT-80 line numbers.

If a typing error is made while entering or editing a line, use the Delete key (←) to delete the incorrect character(s). If, while typing a line, you wish to erase the entire line and start over, type shift ←.

When you wish to stop entering lines and return to command level, type the <break> key after the next available line number.

1.3 Ending the Editing Session

To exit EDIT-80, enter the Exit command:

```
*E  
—
```

The Exit command writes the edited file to disk under the filename that was used to create the file. Subsequent editing sessions with that file require that a filename be specified with the Exit

command. See Section 6.1.

To exit EDIT-80 without writing the edited file to disk, enter the Quit command:

*Q

After execution of a Quit command, all the changes entered during the editing session are lost.

1.4 Line Numbers and Ranges

Most commands to EDIT-80 require a reference to a line number or a range of line numbers. A line number is specified by using the number itself (it is not necessary to type the leading zeros), or one of three special characters that EDIT-80 recognizes as line numbers. These special characters are:

.	(period)	refers to the current line
^	(up arrow)	refers to the first line
*	(asterisk)	refers to the last line

Ranges may be specified in one of two ways:

1. With a colon. The designation

200:1000

means all lines from line number 200 to line number 1000, inclusive. If lines 200 and 1000 do not exist, the range will begin with the first line number greater than 200 and end with the last line number less than 1000.

2. With an exclamation point. The designation

200!3

means the range of three lines that starts with line 200. If line 200 does not exist, 200!3 means the range of three lines that starts with the first line after 200.

Here are some examples of line and range specifications (shown here with the Print command):

P.:2000 Prints the range that begins with
the current line and ends with
line 2000.

P500 Prints line 500.

P. Prints the current line.

P.!15 Prints the range that begins at the current line and ends after the next 15 lines.

PA:1500 Prints the range that begins with
the first line and ends with
line 1500.

PA:* Prints the entire file.

See Appendix C for more examples of range specification.

1.5 Format Notation

Throughout this document, generalized formats of EDIT-80 commands are given to guide the user. These formats employ the following conventions:

1. Items in square brackets are optional.
2. Items in capital letters must be entered as shown.
3. Items in lower case letters enclosed in angle brackets are to be supplied by the user:

```
<position>    supply any line number (up
                to five digits) or ".", "^"
                or "*"

```

```

<range>      supply any <position> or
               any <range>
               <range> = <position>:<position>
                           or
                           <position>!<number>

```

```
<inc>      supply a non-zero integer
            to be used as an increment
            between line numbers
```

```
<filename>    supply any legal TRSDOS
               filename as described
               in Section 1.2
```

4. Punctuation must be included where shown.
5. Items separated by a vertical line are mutually exclusive. Choose one.
6. `<break>` refers to the break key and is echoed as `$`. If you see a `$` in a format notation, it refers to the break key.

7. In any command format, spaces and tabs are insignificant, except within a line number or a filename.
8. Underlined items are typed by EDIT-80.

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CHAPTER 2

Beginning Interline Editing

Editing a file by printing, inserting, deleting and replacing entire lines or groups of lines is termed interline editing. This section describes the commands used to perform these functions.

2.1 Insert Command

The Insert command is used to insert lines of text into the file. EDIT-80 types each line number for you during insert mode. The format of the Insert command is:

I[<position>[,<inc> | ;<inc>]]

Insertion of lines begins at <position> and continues until <break> is typed or until the available space at that point in the file is depleted. (In either case, EDIT-80 returns to command level.)

If no <inc> is included with the command, the default is the permanent increment. ,<inc> specifies a new increment that is then established as the permanent increment. ;<inc> specifies a temporary increment for use with the current command, but does not change the permanent increment.

If no argument is supplied with the Insert command (I<enter>), insertion resumes where the last insert command was terminated, using the last temporary increment. If only <position> is supplied (I<position><enter>), the permanent increment is used.

EDIT-80 will not allow insertion where a line already exists. If <position> is a line number that already exists, the command I<position> will add the permanent increment (or the temporary increment, if one was specified) to <position> and allow insertion at line number <position>+<inc>. If line <position>+<inc> already exists, or if line numbers exist between <position> and <position>+<inc>, an error message will be printed.

The line feed (↓) key may be used to start a new physical line without starting a new logical line, thus providing compatibility with Microsoft BASIC

source files.

Here is an example using the Insert command:

```

*I7740,10
07740
-----
07750
-----
07760 $
*
-
K=K+1
GO TO 400

```

Note that the insertion is terminated with <break>. The <break> key may be typed at the end of the last line inserted (instead of <enter>) or at the beginning of the next line. A line is not saved if <break> is the first key typed on that line.

2.2 Delete Command

The Delete command removes a line or range of lines from the file. The format of the command is:

D<range>

After a Delete command is executed, the current line (".") is set to the first line of the deleted range.

Examples of the Delete Command:

```

D7000      delete line 7000

D.         delete the current line

D200:900   delete lines 200 through 900

D2000:*    delete all lines from line
           2000 through the last line

```

2.3 Replace Command

The Replace command combines the effects of the Delete and Insert commands. The format of the command is:

R<range>[,<inc> | ;<inc>]

The Replace command deletes all of the lines in <range>, then allows the user to enter new text as if an Insert command had been issued. (EDIT-80 types the line numbers.)

The options for selecting the increment between

line numbers are the same as those for the Insert command (see Section 2.1).

Here is an example using the Replace command:

```
*R500:600;50
00500          DO 80 I=1,7
00550          Y(I)=ALOG(Y(I))
00600 80       CONTINUE
*
```

In the above example, the lines in the range 500 to 600 were deleted and replaced by three new lines (500, 550 and 600), using a temporary increment of 50. Insertion terminated automatically because there was not enough room for EDIT-80 to create line 650.

2.4 Print Command

The Print command prints lines at the terminal. The format of the command is:

P<range>

Examples of the Print command:

P.:700 print all lines from the
 current line through line 700

P800:* print all lines from line 800
 through the end of the file

Typing <line feed> (↓) at command level will cause the line after the current line to be printed. Typing <break> at command level will cause the line before the current line to be printed. Typing P<enter> will cause the next 10 lines to be printed.

2.5 List Command

The List command

L<range>

is the same as the Print command, except the output goes to the line printer.

2.6 Number Command

The Number command renumbers lines of text. You may wish to renumber lines to "make room" for an insertion, or just to organize the line numbers in a file. The format of the Number command is

$$N[\langle \text{start} \rangle][, \langle \text{inc} \rangle \mid ; \langle \text{inc} \rangle][= \langle \text{range} \rangle]$$

where:

1. $\langle \text{start} \rangle$ is the first number of the new sequence. If $\langle \text{start} \rangle$ is omitted but $\langle \text{range} \rangle$ is included, $\langle \text{start} \rangle$ is set to the first line of $\langle \text{range} \rangle$. If $\langle \text{start} \rangle$ and $\langle \text{range} \rangle$ are omitted, but $\langle \text{inc} \rangle$ is included, $\langle \text{start} \rangle$ is set to $\langle \text{inc} \rangle$. If $\langle \text{start} \rangle$ is omitted and $\langle \text{inc} \rangle$ is included and $\langle \text{range} \rangle$ specifies only a page number (e.g., $=/2$), $\langle \text{start} \rangle$ is also set to $\langle \text{inc} \rangle$ on that page. If $\langle \text{start} \rangle$, $\langle \text{range} \rangle$ and $\langle \text{inc} \rangle$ are omitted, $\langle \text{start} \rangle$ is set to the permanent increment.
2. $\langle \text{inc} \rangle$ is the increment between line numbers in the new sequence. The options for selection of the increment are the same as those described for the Insert command (see Section 2.1).
3. $\langle \text{range} \rangle$ is the range of line numbers to be renumbered. If $\langle \text{range} \rangle$ is omitted, the entire file is renumbered.

If the current line is renumbered, "." is reset to the same physical line.

If a Number command would result in line numbers being placed out of sequence, or if EDIT-80 cannot fit all the lines using the given increment, an "Out of order" error message is returned.

Due to EDIT-80's internal memory requirements for executing a Number command, an attempt to renumber a very large file may result in an "Insufficient memory" error. If this situation arises, renumber a smaller portion of the file, write it to disk, renumber another portion, and so on. (See Write Command, Section 6.3.)

Examples of the Number command:

N7000;100=200:1000	Lines 200 through 1000 will be renumbered to begin at line 7000 and increment by 100.
--------------------	---

N,10=400:*	Lines 400 through the end will be renumbered to begin with 400 and increment by 10.
N9000=10000:*	Using the permanent increment lines 10000 through the end will be renumbered to begin at 9000.
N,100	Renumber the whole file using increment 100.
N,5=2350!10	This command could be used to make room for an insert by compactifying the ten lines starting with 2350.

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CHAPTER 3

Intraline Editing - Alter Mode

The interline editing commands discussed thus far let you edit by inserting, deleting or replacing entire lines. Of course many editing situations require changes to an existing line but not necessarily retyping of the line. Editing a line without retyping it is called intraline editing, and it is done in Alter mode.

3.1 Alter Command

The Alter command is used to enter Alter mode. The format of the command is:

A<range>

In Alter mode, EDIT-80 types the line number of the line to be altered and waits for an Alter mode subcommand.

3.2 Alter Mode Subcommands

Alter mode subcommands are used to move the cursor; search for text; or insert, delete or replace text within a line. The subcommands are not echoed on the terminal.

Many of the Alter mode subcommands may be preceded by an integer, causing the command to be executed that number of times. (When no integer is specified, the default is always 1.) In many cases, the entire command may also be prefaced with a minus sign (-) which changes the normal direction of the command's action. For example:

D	deletes the next character
6D	deletes the next 6 characters
-D	deletes the last character
-12D	deletes the last 12 characters

Each Alter mode subcommand is described below. A summary of the subcommands is given in Appendix B.

NOTE

In the following descriptions, \$ represents <break>, <ch> represents any character, <text> represents a string of characters of arbitrary length and i represents any integer.

3.3 Cursor Position

The following commands or terminal keys are used to change the position of the cursor in the line. The location of the cursor is called the "current position."

- <space> spaces over characters. i<space> moves the cursor i characters to the right. -i<space> moves the cursor i characters to the left. Characters are printed as you space over them.
- moves the cursor to the end of the line. If preceded by a minus sign, moves the cursor to the beginning of the line.
- L prints the remainder of the line and positions the cursor at the beginning of the line. Proceed with the next Alter mode subcommand.
- P prints the remainder of the line and recycles the cursor to the current position. Proceed with the next Alter mode subcommand.
- W moves to the beginning of the next word. A word is defined as a contiguous collection of letters, numbers, ".", "\$", or "%". iW advances the cursor over the next i words. -iW moves the cursor back through i words to the left.

3.4 Insert Text

- I inserts text. I<text>\$ inserts the given text beginning at the current position. Note that the text must be followed by a <break> or by <enter>.

- B inserts spaces (blanks) at the current position. The B command may be preceded by an integer to insert that many spaces. Spaces are inserted to the right of the cursor only.
- G inserts characters. iG<ch> inserts i copies of <ch>.
- X extends a line. The X subcommand types the remainder of the line, goes into insert mode and lets you insert text at the end of the line. The -X subcommand moves to the beginning of the line and goes into insert mode. (Don't forget to end your insertion with <break> or <enter>.)

3.5 Delete Text

- D deletes the character at the current position. iD deletes i characters beginning at the current position. -iD deletes i characters to the left of the current position. Deleted characters are surrounded by double exclamation points.
- ← The back-arrow key may also be used to delete characters. The character immediately to the left of the current position is deleted. i<back-arrow> is equivalent to -iD.
- H deletes (hacks) the remainder of the line to the right of the cursor (or to the left of the cursor if -H is typed) and enters the insert mode. Text insertion proceeds as if an I command had been typed.
- K deletes (kills) characters. K<ch> deletes all characters up to but not including <ch>. iK<ch> deletes all characters up to the ith occurrence of <ch>. -iK<ch> deletes all characters up to and including the ith previous occurrence of <ch>. If <ch> is not found, the command is not executed.

- O deletes (obliterates) text. O<text>\$ deletes all text up to but not including the next occurrence of <text>. iO<text>\$ deletes all text up to the ith occurrence of <text>. -iO<text>\$ deletes all characters up to and including the ith previous occurrence of <text>.
- T deletes (truncates) the remainder of the line to the right of the cursor (or to the left of the cursor if -T is typed) and exits Alter mode.
- Z deletes (zaps) words. iZ deletes the next i words. -iZ deletes words to the left of the cursor.

3.6 Replace Text

- R replaces text. iR<text>\$ deletes the next i characters and replaces them with <text>. -iR<text>\$ replaces text to the left of the cursor. The deleted characters are echoed between double exclamation points.
- C changes characters one character at a time. C<ch> changes the next character to <ch>. Only the new character is echoed. iC may be followed by i characters to change that many characters; or it may be followed by fewer than i characters and terminated with <break>, in which case the remaining characters will not be changed. -iC does an i<back arrow> and then an iC. The i<back arrow> is echoed between exclamation points.

3.7 Find Text

- S searches for a character. S<ch> searches for the next occurrence of <ch> after the current position and positions the cursor before the character. iS<ch> searches for the ith occurrence of <ch>. -S<ch> and -iS<ch> search for the (ith) previous occurrence of <ch> and position the cursor immediately before it. The character at the cursor position is not included in the search. If <ch> is not found, the command is ignored.

F finds text. F<text>\$ finds the next occurrence of <text> and positions the cursor at the beginning of the string. iF<text>\$ finds the ith occurrence of <text>. -F<text>\$ and -iF<text>\$ find the (ith) previous occurrence of <text> and position the cursor before it.

3.8 Ending and Restarting Alter Mode

<cr> carriage return. Prints the remainder of the line, enters the changes and concludes altering of that line.

A same as carriage return.

E enters the changes and concludes altering of that line, but does not print the remainder of the line.

N restores the original line (changes are not saved) and either moves to the next line (if an A<range> command is still in progress), or returns to command level.

Q restores the original line (changes are not saved), exits (quits) Alter mode, and returns to command level.

Shift ← Restores the original line, stays in Alter mode and repositions the cursor at the beginning of the line. Echoes as AY.

3.9 Extend Command

The Extend command is issued at command level and is used to extend lines. The format of the command is

X<range>

The effect of the X command is equivalent to typing an A command, followed by an X subcommand. After entering an X command, proceed by typing the text to be inserted at the end of the line. Don't forget you are now in Alter mode and may use any of the Alter mode subcommands, once <break> has been typed.

The Extend command is particularly useful for placing comments in assembly language programs.

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CHAPTER 4

Find and Substitute Commands

When it is necessary to change a certain portion of text, it is not always immediately known where that text is located in the file. Even with a listing of the file on hand, it is a tiresome task to scan the listing to find the line number of a particular item that must be changed.

The EDIT-80 Find and Substitute commands allow the user to quickly locate text and make necessary changes.

4.1 Find Command

The Find command locates a given string of text in the file and types the line(s) containing that string. The format of the command is:

```
F[<range>][,<limit>] <enter> | $<string>$
```

where \$ represents the escape key and <limit> is the number of lines containing <string> to be found. A limit of zero will find all occurrences of <string>. The following rules apply to the format of the Find command:

1. If \$<string>\$ is omitted, the last string given in a Find command is used.
2. If <limit> is omitted and \$<string>\$ is included, <limit> is assumed to be 1.
3. If <limit> and \$<string>\$ are omitted, the previous limit is assumed.
4. If <range> is omitted and \$<string>\$ is included, the entire range from the previous Find command is used.
5. If <range> and \$<string>\$ are omitted, the search for the previous string continues from the line where the last occurrence was found.

If the search is unsuccessful, an error message is printed.

Here is a sample editing session using Find:

```
*F^:*$WHI(I)$
01100   WHI(I)=0
*F<enter>
01400   IF (P.GT.WHI(I))WHI(I)=P
*A.
01400   .
.
.
*F,2$WLO(I)$
01200   WLO(I)=9999
01500   IF (P.LT.WLO(I))WLO(I)=P
*A.
01500   .
.
.
*F.:*$AVG$
Search fails
*F$MEAN$
03700   MEAN=SUM/40
*F,0
04200   IF (P.GT.MEAN) M=M+1
06700   WRITE (6,170) MEAN, M
*A4200
04200   .
.
.
```

Find the first line that contains WHI(I). Prints line 1100. Find the next one. Prints line 1400. Caught a mistake in this line. Alter it.

Find the first two lines in the file that contain WLO(I) (range is still .*). Prints lines 1200 and 1500. Alter line 1500.

Find the first line in the file that contains AVG. There aren't any. Try finding MEAN instead. Prints line 3700. Find all other lines containing MEAN. (Search begins at the line after line 3700.) Finds two more (4200 and 6700). Alter line 4200, etc.

4.2 Substitute Command

The Substitute command locates a given string, replaces it with a new string and types the new line(s). The format of the command is:

S[<range>][,<limit>] <enter> | \$<old string>\$<new string>\$

where \$ represents <break>, and <limit> is the number of lines in which <old string> is to be replaced by <new string>. A limit of zero will replace all occurrences of <old string> with <new string>. <new string> may be a null string. The following rules apply to the format of the Substitute command:

1. If \$<old string>\$<new string>\$ are omitted, the strings given in the last Substitute command are used.
2. If <limit> is omitted and \$<old string>\$<new string>\$ are included, <limit> is assumed to be zero.
3. If <limit> and \$<old string>\$<new string>\$ are omitted, the previous limit is assumed.
4. If <range> is omitted and \$<old string>\$<new string>\$ are included, the entire range from the previous Substitute command is used.
5. If <range> and \$<old string>\$<new string>\$ are omitted, substitution continues from where the last substitution left off.

If no occurrence of <old string> is found, an error message is printed.

Example:

```
*SA:5000$ALPHA$BETA$
00950  BETA(K)=ABS(1.-LST(K))
01750  WRITE(6,400) BETA(K)
04100  IF (BETA(K).LT.0)GOTO 9000
```

From the first line to line 5000, replace all occurrences of ALPHA with BETA.

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CHAPTER 5

Pages

It is possible to divide an EDIT-80 file into sections called pages, which are separated by page marks. The first page of a file is always page 1, and EDIT-80 always enters command level on page 1 of a multiple-page file. Each subsequent page begins with a page mark and is numbered sequentially. On any given page, the complete range of line numbers (00000 to 99999 or any portion thereof) may be used.

If EDIT-80 encounters a form feed while reading in a file, it will enter a page mark at that point in the file. If EDIT-80 encounters a line number that is less than the previous line number, it will automatically insert a page mark so that proper line number sequence may be maintained. When EDIT-80 writes a file out to disk, a form feed is output with each page mark. Then, when the file is listed, each new page of the file starts on a new physical page.

5.1 Specifying Page Numbers

In a single-page file, only a line number is needed to indicate <position>. In a multiple-page file, EDIT-80 must know the page number as well as the line number to determine a <position>. That is, <position> is indicated by

<line>[/<page>]

where

<line> is ".", "^", "*" or a number of up to five digits.

<page> is ".", "^", "*" or a number of up to five digits. When specifying a page, the characters ".", "^" and "*" refer to the current page, the first page and the last page, respectively. If <page> is omitted, the current page is assumed.

Consequently, in a multiple-page file a <range>, which may be indicated by

<position>:<position>
or
<position>!<number>

may also contain page numbers. If the page number is omitted from the first line number in the range, it is assumed to be the current page. If the page

number is omitted from the second line number in the range, it is assumed to be on the same page as the first line number in the range.

Here are some examples of line numbers and ranges that include page number specification:

100/2:*/*	Line 100 on page 2 through the last line on the last page
100/2:*	Line 100 on page 2 through the end of that page
100:*/5	Line 100 on the current page through the last line on page 5
100/*	Line 100 on the last page
100/.*:/3	Line 100 on the current page through the last line on page 3

See Appendix C for more examples of range specification.

5.2 Inserting Page Marks

Page marks may be inserted in the file at the discretion of the user. To insert a page mark, use the Mark command. The format is:

M<position>

The page mark is inserted immediately after <position>. <position> must exist or an error message will be printed.

The current line reference (".") is retained after a Mark command is executed. That is, if <position> is before ".", then "." will be moved to the next page and will still point to the same physical line.

5.3 Deleting Page Marks

Page marks are deleted with the K (Kill) command. The format of the command is:

K/<page>

The K command deletes the page mark after <page>. For example, in a four-page file, K/2 would delete

the second page mark (the page mark that started page 3), and the pages would then be numbered 1, 2, and 3. The last line number on <page> must be lower than the first line number on <page>+1 before a K/<page> command can be executed.

5.4 Begin Command

Use the Begin command to return to the beginning of a page. The format of the Begin command is:

B[/<page>]

If <page> is omitted, the B command returns to the beginning of page one.

5.5 Other Commands and Page Marks

1. A Delete command that crosses over a page boundary will delete all lines in the range, but will not delete the page mark.
2. A Print command that moves off the current page will print the new page number prior to printing the first line specified in the command.
3. When output is being done with the List command, a form feed will be printed with each page mark, and the page number will be printed on each page.
4. A range specified with an exclamation point may cross a page boundary.
5. If the range specified in a Number command crosses page boundaries, numbering will start over on each new page; the first line number will equal the increment. Consequently, in the Number command, <start> and the first line of <range> must be on the same page.

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CHAPTER 6

Exiting EDIT-80

Section 1.3 introduced the Exit and Quit commands for exiting EDIT-80. These two commands will be described more completely in this chapter. An additional command, the Write command, will also be presented.

6.1 Exit Command

The Exit command is used to write the file to disk and return to TRSDOS. The format of the command is:

E[<filename>][-<switch>]

The edited file is saved on the disk under <filename>. When exiting a new file for the first time, <filename> may be omitted. (In which case, the opening filename is assigned.) Otherwise, a new filename is required for each Exit. The previous file serves as a back-up.

The optional <switch> controls the format of the output. (See Section 6.5.)

6.2 Quit Command

The Quit command is used to return to TRSDOS without writing the edited file to disk. To Quit editing, simply enter:

Q

After a Quit command, all changes entered during the editing session are lost.

6.3 Write Command

The Write command writes the edited text to disk and then returns to EDIT-80 command level. It does not exit the editor, and the current position in the file is not changed. The format of the command is:

W[<filename>][-<switch>]

A filename is not required in the first Write of a new file. A filename is required, however, in all subsequent Write and Exit commands.

The optional <switch> controls the format of the output. (See Section 6.5.)

6.4 Index Files

When reading in a file to be edited, EDIT-80 generates information it needs about each block of the disk file. With a small file, this information is generated in a few seconds, each time the file is read in. However, with larger files (5K or more), the time lag required to read in the file becomes significant. Thus, when EDIT-80 saves a file of 42 or more records on the disk, it also saves a small file, separate from the text file, containing the required information about the text file.

This small file is called the index file, and it can be read faster than the text file. EDIT-80 saves the index file under a filename that is the same as the text filename (passwords not included), with a Z preceding the first two letters of the extension. For example, if the file is called FOO/MAC.SAM, the index file is called FOO/ZMA.

When EDIT-80 is asked to edit a file, it first checks for an index file. If an index file exists, EDIT-80 reads the index file instead of the text file. Care must be taken if the text file is modified by another editor or changed and saved in BASIC. The user must then delete the index file prior to editing the text file again with EDIT-80. If the index file is not deleted, EDIT-80 will have meaningless information about the text file.

6.5 Parameters

When reading in a file, EDIT-80 expects it to be in its own representation. If the file appears to be in another representation, EDIT-80 will add line numbers and try to convert the file to EDIT-80 standard format. There are, however, several other representations that EDIT-80 accepts, if the proper switch is appended to the input filename. Switches are always preceded by a dash (-):

filename[/ext][.password][:drive#][-switch]

For example: FOO/BAS.SAM-BASIC

6.5.1 BASIC Switch

If the BASIC switch is appended to the input filename, EDIT-80 will read the file using the following algorithm:

1. All leading spaces and tabs are removed from each line.
2. The first non-blank character must be a digit.
3. From 1 to 5 leading digits are converted to a line number. More than 5 leading digits constitutes a fatal error.
4. A tab is inserted if the first non-digit is not a space or a tab. If the first non-digit is a space, it is replaced by a tab. If the first non-digit is a tab, it is left alone.
5. On output, if UNSEQ (see Section 6.5.2) has been selected, leading zeros in the line number are suppressed and the tab is converted to a space.

Because BASIC uses line numbers to control the sequence of program execution, BASIC users should beware of renumbering with the N command. Microsoft BASIC will ignore page marks from the EDIT-80 file, so a BASIC file may have multiple pages. Insure, however, that no line number appears more than once in the program.

6.5.2 SEQ and UNSEQ Switches

If the SEQ switch is appended to the input filename, EDIT-80 will use the same algorithm to interpret the text file as with the BASIC switch. However, when the file is output, it will be in standard EDIT-80 format, unless the UNSEQ switch is appended to the output filename.

The UNSEQ switch on input tells EDIT-80 to append its own line numbers to the incoming file, regardless of what it looks like. This switch must be used if the incoming file has digits at the beginning of lines with high bits on that are not to be interpreted as line numbers.

On output, the UNSEQ switch must be specified (if it hasn't been already) to output a non-standard file. That is, if BASIC is specified on input and UNSEQ is specified on output, the file will be output in BASIC format. If BASIC was not specified

on input and UNSEQ is specified on output, the file will be output with no line numbers and no trailing tab. If the UNSEQ switch was specified on input and the user wishes to output a standard file, the SEQ switch on output will override the UNSEQ switch.

APPENDIX A

Alphabetic Summary of Commands

<u>Command</u>	<u>Format and Description</u>	<u>Page</u>
Alter	A<range> Enters Alter mode.	15
Begin	B[<page>] Moves to the beginning of <page>. Default is page 1.	25
Delete	D<range> Deletes lines.	11
Exit	E[<filename>][-<switch>] Writes the edited text to disk and exits the editor.	6, 26
Find	F[<range>][,<limit>] <enter> \$<string>\$ Finds occurrences of <string>.	20
Insert	I[<position>][,<inc> ;<inc>] Inserts lines beginning at <position> using increment <inc>. With no argument, continues with previous Insert command.	10
Kill	K/<page> Deletes the page mark at the end of <page>.	24
List	L<range> Prints lines at the line printer.	12
Mark	M<position> Inserts a page mark after <position>.	24
Number	N[<start>][,<inc> ;<inc>][=<range>] Renumbers the lines in <range> so they begin at <start> and increment by <inc>.	13
Print	P[<range>] Prints lines at the terminal. With no argument, prints the next 20 lines.	12
Quit	Q Exits the editor without writing the edited text to disk.	6, 26

Replace	R<range>[,<inc> ;<inc>] Replaces line(s) using increment <inc>.	18
Substitute	S[<range>][,<limit>]<enter> \$<old string>\$<new string>\$ Replaces <old string> with <new string>.	22
Write	W[<filename>][-<switch>] Writes the edited text to disk but does not exit the editor.	26
eXtend	X<range> Allows insertion of text at the end of a line.	19

APPENDIX B

Alphabetic Summary of Alter Mode Subcommands

<u>Command</u>	<u>Format</u>	<u>Action</u>
A	A	Prints the remainder of the line, enters the changes and concludes altering of that line
B	[i]B	Inserts spaces
C	[-][i]C<ch>[...<ch>]	Replaces characters
D	[-][i]D	Deletes characters
E	E	Enters the changes and concludes altering of that line
F	[-][i]F\$<text>\$	Finds <text>
G	[i]G<ch>	Inserts i copies of <ch>
H	[-]H<text>\$	Deletes the remainder of the line and enters the insert mode
I	I<text>\$	Inserts <text>
K	[-][i]K<ch>	Deletes all characters up to <ch>
L	L	Positions the cursor at the beginning of the line
N	N	Restores the original line and either moves to the next line (if an A<range> command is still in progress) or returns to command level
O	[-][i]O<text>\$	Deletes all characters up to <text>
P	P	Recycles the cursor to the current position
Q	Q	Exits Alter mode and restores the original line

R	[-][i]R<text>\$	Replaces i characters with <text>
S	[-][i]S<ch>	Finds <ch>
T	[-]T	Deletes the remainder of the line and concludes altering of the line
W	[-][i]W	Moves the cursor over words
X	[-]X	Extends the line
Z	[-][i]Z	Deletes words
[-] →		Moves the cursor to the end of the line
←		Deletes characters
[-][i]<space>		Moves the cursor over characters
<enter>		Prints the remainder of the line, enters changes and concludes altering of that line
Shift ←		Restores the original line, stays in Alter mode and repositions the cursor at the beginning of the line. Echoes as ↑Y.

APPENDIX C

Summary of Notation

The notation used in this document may be defined as follows:

$\langle \text{line} \rangle = \langle \text{number} \rangle \mid . \mid \wedge \mid *$
 $\langle \text{page} \rangle = \langle \text{number} \rangle \mid . \mid \wedge \mid *$
 $\langle \text{position} \rangle = \langle \text{line} \rangle [/ \langle \text{page} \rangle]$
 $\langle \text{range} \rangle = \langle \text{position} \rangle [: \langle \text{position} \rangle \mid ! \langle \text{number} \rangle]$

where:

$\langle \text{number} \rangle = \langle \text{digit} \rangle \mid \langle \text{number} \rangle \langle \text{digit} \rangle$
 $\langle \text{digit} \rangle = 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$

Shorthand Notation for Ranges

The following "shorthand" forms of range specifications may be used with EDIT-80 commands.

<u>Shorthand Notation</u>	<u>Equivalent To</u>	<u>Range Specified</u>
$/\langle \text{page} \rangle$	$\wedge / \langle \text{page} \rangle : * / \langle \text{page} \rangle$	All of $\langle \text{page} \rangle$.
$/\langle \text{page1} \rangle : / \langle \text{page2} \rangle$	$\wedge / \langle \text{page1} \rangle : * / \langle \text{page2} \rangle$	The first line on $\langle \text{page1} \rangle$ through the last line on $\langle \text{page2} \rangle$.
$:$	$\wedge / 1 : * / *$	The entire file.
$\langle \text{position} \rangle :$	$\langle \text{position} \rangle : * / *$	$\langle \text{position} \rangle$ through the end of the file. e.g., .. $:$ is the same as $./ : * / *$
$: \langle \text{position} \rangle$	$\wedge / 1 : \langle \text{position} \rangle$	The first line in the file through $\langle \text{position} \rangle$. e.g., .. $:$ is the same as $\wedge / 1 : ./$.

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APPENDIX D

EDIT-80 Special Characters

<break>	Aborts the command in progress and returns to EDIT-80 command level.
→	Types a tab.
Shift ←	Erases the line being typed and lets you start over. When used in Alter mode, Shift<-- restores the original line, stays in Alter mode and repositions the cursor at the beginning of the line.

Control characters are typed by holding down the shift key, the down-arrow (↓) key and the correct alpha key at the same time.

Control O	Suspends/resumes output (at the terminal or line printer) from an EDIT-80 command.
Control S	Halts/resumes execution of an EDIT-80 command.

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APPENDIX E

Error Messages

Fatal Errors

Disk I/O errors are fatal. The corresponding TRSDOS error message will be printed.

Any TRSDOS system error message is fatal.

Illegal line format

Occurs when EDIT-80 finds a line with strange contents or a strange line number. This should not normally occur when editing a file created by EDIT-80. It is usually caused by reading files not meant for editing, such as binary files.

Edit Error MessagesIllegal command

Tells the user a nonexistent or ill-formed command was typed.

Insufficient memory available

Occurs when the user has made enough changes to the file to have exhausted EDIT-80's memory area. This should only happen when a large file has many changes or when large portions of code are being inserted or renumbered. A W command should be done to compress memory.

No string given

Tells the user the F or S command was given without a search string. This usually happens when using the F or S command with no arguments prior to issuing an F or S command with arguments, or when an <escape> without a search string is typed following the range.

No such line(s)

This message is issued if a command references a line or range which does not exist. Usually occurs when the proper page number is omitted from the line or range.

Line too long

This message is issued when the user attempts to enter a line longer than 255 characters. This may happen when the line is read or as a result of a command which alters the line.

Out of order

Indicates that the line numbers in the file would not be in ascending order if the command were to be executed. This frequently happens when trying to insert where there is not

enough room or trying to delete a page mark.

Search fails

An informative message that tells the user a search was unsuccessful.

Wrap around

This message is printed whenever a line greater than 99999 would be generated.

File Errors

File already exists

Issued if the user tries to give the name of an existing file to a new file, or tries to rename a file using the name of an existing file in an E or W command.

File not found

Issued if the file specified in a command could not be found.

Illegal file specification

Informs the user that the command string contains an illegal character of some kind.

APPENDIX F

Output File Format

Compilers and assemblers should ignore the line numbers and page marks included in EDIT-80 output files (except when included in listing files). Microsoft TRS-80 FORTRAN and MACRO-80 both do so.

A line number consists of five decimal digits followed by a tab character. All six bytes have the high order bit (bit 7) equal to one. It is not recommended that EDIT-80 files be listed with the TRSDOS LIST command. Graphics characters may appear in the line numbers. Use EDIT-80's Print command instead.

When writing a file with -BASIC set, the line numbers have the high order bits equal to zero. Each line number is followed by a space that has the high order bit equal to zero.

A page mark is a form feed character with the high order bit equal to one.

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SECTION 1

MACRO-80 Assembler

Assembly language programs and subroutines are assembled with MACRO-80. Just as the FORTRAN compiler generates relocatable object code from a FORTRAN program, MACRO-80 generates relocatable object code from an assembly language program. Running MACRO-80 is very similar to running the FORTRAN compiler, and the command format is identical. The default extension for a MACRO-80 source file is /MAC.

1.1 Running MACRO-80

When you give TRSDOS the command

M80

(diskette #1 must be in the disk drive), you are running the MACRO-80 assembler. When the assembler is ready to accept commands, it prompts the user with an asterisk. To exit the assembler, use the <break> key.

Command lines are also supported by MACRO-80. After executing a command line, the assembler automatically exits to the operating system.

1.1.1 Command Format

An assembler command conveys the name of the source file you want to assemble, and what options you want to use. Here is the format for an assembler command (square brackets indicate optional):

[object filename][,listing filename]=source filename[-switch...]

NOTE

All filenames must be in TRSDOS filename format:

filename[/ext][.password][:drive#]. If you are using the assembler's default extensions, it is not necessary to specify an extension in an assembler command.

Let's look individually at each part of the assembler command:

1. Object filename

To create a relocatable object file, this part of the command must be included. It is simply the name that you want to call the object file. The default extension for the object filename is /REL.

2. Listing filename

To create a listing file, this part of the command must be included. It is simply the name that you want to call the listing file. The default extension for the listing file is /LST.

3. Source filename

An assembler command must always include a source filename -- that is how the assembler "knows" what to assemble. It is simply the name of a MACRO-80 program you have saved on disk. The default extension for a MACRO-80 source filename is /MAC. The source filename is always preceded by an equal sign in an assembler command.

Examples (asterisk is typed by M80):

*=TEST	Assemble the program TEST/MAC without creating an object file or listing file.
--------	--

*TEST,TEST=TEST	Assemble the program TEST/MAC. Create a relocatable object file called TEST/REL and a listing file called TEST/LST.
-----------------	---

*,TEST.PASS=TEST.PASS	Assemble the program TEST/MAC.PASS and create a listing file called TEST/LST.PASS (No object file created.)
-----------------------	---

*TESTOBJ=TEST	Assemble the program TEST/MAC and create an object file called TESTOBJ/REL. (No listing file created.)
---------------	--

4. Switch

A switch on the end of a command specifies a special parameter to be used during assembly. Switches are always preceded by a dash (-). More than one switch may be used in the same

command. The available switches are:

<u>Switch</u>	<u>Action</u>
O	Print all listing addresses in octal.
H	Print all listing addresses in hexadecimal (default condition).
C	Force generation of a cross reference file.
Z	Assemble Z80 (Zilog format) mnemonics (default condition).
I	Assemble 8080 mnemonics.

Examples:

*CT.ME,CT.ME=CT.ME-O Assemble the program CT/MAC.ME. Create a listing file called CT/LST.ME and an object file called CT/REL.ME. The addresses in the listing file will be in octal.

*LT,LT=LT-C Assemble the program LT/MAC. Create an object file called LT/REL, a listing file called LT/LST, and a cross reference file called LT/CRF. (See Section 1.12.)

1.1.2 Input/Output Device Names

In the commands discussed so far, it is assumed that all files are read from and written to the disk. To use an I/O device other than the disk, specify the device name in place of the filename in the assembler command.

The device names supplied by TRSDOS are:

*KI	Keyboard Input
*DO	Display Output
*PR	Printer Output

(*DO and *PR are available only with TRSDOS Version 2.2 or later.)

Examples:

TEST,*PR=TEST Assemble the program TEST/MAC.
 Create an object file called
 TEST/MAC and output the
 listing file, TEST/LST, at
 the printer.

TEST,*DO=TEST Assemble the program TEST/MAC.
 Create an object file called
 TEST/MAC and output the
 listing file, TEST/LST at
 the video display.

,=*KI KI is used only if you
 want to input a source file
 from the keyboard. This
 command assembles the source
 file read from the
 keyboard without creating
 a REL or LST file.

1.2 Format of MACRO-80 Source Files

In general, MACRO-80 accepts a source file that is almost identical to source files for INTEL compatible assemblers. Input source lines of up to 132 characters in length are acceptable.

MACRO-80 preserves lower case letters in quoted strings and comments. All symbols, opcodes and pseudo-opcodes typed in lower case will be converted to upper case.

NOTE

If the source file includes line numbers from an editor, each byte of the line number must have the high bit on. Line numbers from Microsoft's EDIT-80 Editor are acceptable.

1.2.1 Statements

Source files input to MACRO-80 consist of statements of the form:

[label[:]] [operator] [arguments] - [;comment]

With the exception of the ISIS assembler \$ controls (see Section 1.10), it is not necessary that

statements begin in column 1. Multiple blanks or tabs may be used to improve readability.

If a label is present, it is the first item in the statement and is immediately followed by a colon. If it is followed by two colons, it is declared as PUBLIC (see ENTRY/PUBLIC, Section 1.5.10). For example:

```
FOO::    RET
```

i, equivalent to

```
PUBLIC    FOO
FOO:     RET
```

The next item after the label (or the first item on the line i, no label is present) is an operator. An operator may be an opcode (8080 or Z80 mnemonic), pseudo-op, macro call or expression. The evaluation order is as follows:

1. Macro call
2. Opcode/Pseudo operation
3. Expression

Instead of flagging an expression as an error, the assembler treats it as if it were a DB statement (see Section 1.5.4).

The arguments following the operator will, of course, vary in form according to the operator.

A comment always begins with a semicolon and ends with a carriage return. A comment may be a line by itself or it may be appended to a line that contains a statement. Extended comments can be entered using the .COMMENT pseudo operation (see Section 1.5.19).

1.2.2 Symbols

MACRO-80 symbols may be of any length, however, only the first six characters are significant. The following characters are legal in a symbol:

A-Z 0-9 \$. ? @

The underline character is also legal in a symbol. A symbol may not start with a digit. When a symbol is read, lower case is translated into upper case. If a symbol reference is followed by ## it is

declared external (see also the EXT/EXTRN pseudo-op, Section 1.5.12).

1.2.3 Numeric Constants

The default base for numeric constants is decimal. This may be changed by the .RADIX pseudo-op (see Section 1.5.21). Any base from 2 (binary) to 16 (hexadecimal) may be selected. When the base is greater than 10, A-F are the digits following 9. If the first digit of the number is not numeric (i.e., A-F), the number must be preceded by a zero. This eliminates the use of zero as a leading digit for octal constants, as in previous versions of MACRO-80.

Numbers are 16-bit unsigned quantities. A number is always evaluated in the current radix unless one of the following special notations is used:

nnnnB	Binary
nnnnD	Decimal
nnnnO	Octal
nnnnQ	Octal
nnnnH	Hexadecimal
X'nnnn'	Hexadecimal

Overflow of a number beyond two bytes is ignored and the result is the low order 16-bits.

A character constant is a string comprised of zero, one or two ASCII characters, delimited by quotation marks, and used in a non-simple expression. For example, in the statement

```
DB      'A' + 1
```

'A' is a character constant. But the statement

```
DB      'A'
```

uses 'A' as a string because it is in a simple expression. The rules for character constant delimiters are the same as for strings.

A character constant comprised of one character has as its value the ASCII value of that character. That is, the high order byte of the value is zero, and the low order byte is the ASCII value of the character. For example, the value of the constant 'A' is 41H.

A character constant comprised of two characters has as its value the ASCII value of the first

character in the high order byte and the ASCII value of the second character in the low order byte. For example, the value of the character constant "AB" is $41H * 256 + 42H$.

1.2.4 Strings

A string is comprised of zero or more characters delimited by quotation marks. Either single or double quotes may be used as string delimiters. The delimiter quotes may be used as characters if they appear twice for every character occurrence desired. For example, the statement

```
DB      "I am ""great"" today"
```

stores the string

```
I am "great" today
```

If there are zero characters between the delimiters, the string is a null string.

1.3 Expression Evaluation

1.3.1 Arithmetic and Logical Operators

The following operators are allowed in expressions. The operators are listed in order of precedence.

NUL

LOW, HIGH

*, /, MOD, SHR, SHL

Unary Minus

+, -

EQ, NE, LT, LE, GT, GE

NOT

AND

OR, XOR

Parentheses are used to change the order of precedence. During evaluation of an expression, as soon as a new operator is encountered that has precedence less than or equal to the last operator

encountered, all operations up to the new operator are performed. That is, subexpressions involving operators of higher precedence are computed first.

All operators except +, -, *, / must be separated from their operands by at least one space.

The byte isolation operators (HIGH, LOW) isolate the high or low order 8 bits of an Absolute 16-bit value. If a relocatable value is supplied as an operand, HIGH and LOW will treat it as if it were relative to location zero.

1.3.2 Modes

All symbols used as operands in expressions are in one of the following modes: Absolute, Data Relative, Program (Code) Relative or COMMON. (See Section 1.5 for the ASEG, CSEG, DSEG and COMMON pseudo-ops.) Symbols assembled under the ASEG, CSEG (default), or DSEG pseudo-ops are in Absolute, Code Relative or Data Relative mode respectively. The number of COMMON modes in a program is determined by the number of COMMON blocks that have been named with the COMMON pseudo-op. Two COMMON symbols are not in the same mode unless they are in the same COMMON block.

In any operation other than addition or subtraction, the mode of both operands must be Absolute.

If the operation is addition, the following rules apply:

1. At least one of the operands must be Absolute.
2. Absolute + <mode> = <mode>

If the operation is subtraction, the following rules apply:

1. <mode> - Absolute = <mode>
2. <mode> - <mode> = Absolute
where the two <mode>s are the same.

Each intermediate step in the evaluation of an expression must conform to the above rules for modes, or an error will be generated. For example, if FOO, BAZ and ZAZ are three Program Relative symbols, the expression

FOO + BAZ - ZAZ

will generate an R error because the first step (FOO + BAZ) adds two relocatable values. (One of the values must be Absolute.) This problem can always be fixed by inserting parentheses. So that

FOO + (BAZ - ZAZ)

is legal because the first step (BAZ - ZAZ) generates an Absolute value that is then added to the Program Relative value, FOO.

1.3.3 Externals

Aside from its classification by mode, a symbol is either External or not External. (See EXT/EXTRN, Section 1.5.12.) An External value must be assembled into a two-byte field. (Single-byte Externals are not supported.) The following rules apply to the use of Externals in expressions:

1. Externals are legal only in addition and subtraction.
2. If an External symbol is used in an expression, the result of the expression is always External.
3. When the operation is addition, either operand (but not both) may be External.
4. When the operation is subtraction, only the first operand may be External.

1.4 Opcodes as Operands

8080 opcodes are valid one-byte operands. Note that only the first byte is a valid operand. For example:

```
MVI    A,(JMP)
ADI    (CPI)
MVI    B,(RNZ)
CPI    (INX H)
ACI    (LXI B)
MVI    C,MOV A,B
```

Errors will be generated if more than one byte is included in the operand -- such as (CPI 5), LXI B,LABEL1) or (JMP LABEL2).

Opcodes used as one-byte operands need not be enclosed in parentheses.

NOTE

Opcodes are not valid operands in Z80 mode.

1.5 Pseudo Operations

1.5.1 ASEG

ASEG

ASEG sets the location counter to an absolute segment of memory. The location of the absolute counter will be that of the last ASEG (default is 0), unless an ORG is done after the ASEG to change the location. The effect of ASEG is also achieved by using the code segment (CSEG) pseudo operation and the -P switch in LINK-80. See also Section 1.5.27.

1.5.2 COMMON

COMMON /<block name>/

COMMON sets the location counter to the selected common block in memory. The location is always the beginning of the area so that compatibility with the FORTRAN COMMON statement is maintained. If <block name> is omitted or consists of spaces, it is considered to be blank common. See also Section 1.5.27.

1.5.3 CSEG

CSEG

CSEG sets the location counter to the code relative segment of memory. The location will be that of the last CSEG (default is 0), unless an ORG is done after the CSEG to change the location. CSEG is the default condition of the assembler (the INTEL assembler defaults to ASEG). See also Section 1.5.27.

1.5.4 Define Byte

DB <exp>[,<exp>...]

DB <string>[<string>...]

The arguments to DB are either expressions or strings. DB stores the values of the expressions or the characters of the strings in successive memory locations beginning with the current location counter.

Expressions must evaluate to one byte. (If the high byte of the result is 0 or 255, no error is given; otherwise, an A error results.)

Strings of three or more characters may not be used in expressions (i.e., they must be immediately followed by a comma or the end of the line). The characters in a string are stored in the order of appearance, each as a one-byte value with the high order bit set to zero.

Example:

0000'	4142	DB	'AB'
0002'	42	DB	'AB' AND 0FFH
0003'	41 42 43	DB	'ABC'

1.5.5 Define Character

DC <string>

DC stores the characters in <string> in successive memory locations beginning with the current location counter. As with DB, characters are stored in order of appearance, each as a one-byte value with the high order bit set to zero. However, DC stores the last character of the string with the high order bit set to one. An error will

result if the argument to DC is a null string.

1.5.6 Define Space

DS <exp>

DS reserves an area of memory. The value of <exp> gives the number of bytes to be allocated. All names used in <exp> must be previously defined (i.e., all names known at that point on pass 1). Otherwise, a V error is generated during pass 1 and a U error may be generated during pass 2. If a U error is not generated during pass 2, a phase error will probably be generated because the DS generated no code on pass 1.

1.5.7 DSEG

DSEG

DSEG sets the location counter to the Data Relative segment of memory. The location of the data relative counter will be that of the last DSEG (default is 0), unless an ORG is done after the DSEG to change the location. See also Section 1.5.27.

1.5.8 Define Word

DW <exp>[,<exp>...]

DW stores the values of the expressions in successive memory locations beginning with the current location counter. Expressions are evaluated as 2-byte (word) values.

1.5.9 END

END [<exp>]

The END statement specifies the end of the program. If <exp> is present, it is the start address of the program. If <exp> is not present, then no start address is passed to LINK-80 for that program.

1.5.10 ENTRY/PUBLIC

```
ENTRY  <name>[,<name>...]  
or  
PUBLIC <name>[,<name>...]
```

ENTRY or PUBLIC declares each name in the list as internal and therefore available for use by this program and other programs to be loaded concurrently. All of the names in the list must be defined in the current program or a U error results. An M error is generated if the name is an external name or common-blockname.

1.5.11 EQU

```
<name> EQU <exp>
```

EQU assigns the value of <exp> to <name>. If <exp> is external, an error is generated. If <name> already has a value other than <exp>, an M error is generated.

1.5.12 EXT/EXTRN

```
EXT    <name>[,<name>...]  
or  
EXTRN  <name>[,<name>...]
```

EXT or EXTRN declares that the name(s) in the list are external (i.e., defined in a different program). If any item in the list references a name that is defined in the current program, an M error results. A reference to a name where the name is followed immediately by two pound signs (e.g., NAME##) also declares the name as external.

1.5.13 NAME

```
NAME    ('modname')
```

NAME defines a name for the module. Only the first six characters are significant in a module name. A module name may also be defined with the TITLE pseudo-op. In the absence of both the NAME and TITLE pseudo-ops, the module name is created from the source file name.

1.5.14 Define Origin

ORG <exp>

The location counter is set to the value of <exp> and the assembler assigns generated code starting with that value. All names used in <exp> must be known on pass 1, and the value must either be absolute or in the same area as the location counter.

1.5.15 PAGE

PAGE [<exp>]

PAGE causes the assembler to start a new output page. The value of <exp>, if included, becomes the new page size (measured in lines per page) and must be in the range 10 to 255. The default page size is 50 lines per page. The assembler puts a form feed character in the listing file at the end of a page.

1.5.16 SET

<name> SET <exp>

SET is the same as EQU, except no error is generated if <name> is already defined.

1.5.17 SUBTTL

SUBTTL <text>

SUBTTL specifies a subtitle to be listed on the line after the title (see TITLE, Section 1.5.18) on each page heading. <text> is truncated after 60 characters. Any number of SUBTTLS may be given in a program.

1.5.18 TITLE

TITLE <text>

TITLE specifies a title to be listed on the first line of each page. If more than one TITLE is given, a Q error results. The first six characters of the title are used as the module name unless a NAME pseudo operation is used. If neither a NAME or TITLE pseudo-op is used, the module name is created from the source filename.

1.5.19 .COMMENT

```
.COMMENT <delim><text><delim>
```

The first non-blank character encountered after .COMMENT is the delimiter. The following <text> comprises a comment block which continues until the next occurrence of <delimiter> is encountered. For example, using an asterisk as the delimiter, the format of the comment block would be:

```
.COMMENT *  
any amount of text entered  
here as the comment block  
.  
.  
.*  
;return to normal mode
```

1.5.20 .PRINTX

```
.PRINTX <delim><text><delim>
```

The first non-blank character encountered after .PRINTX is the delimiter. The following text is listed on the terminal during assembly until another occurrence of the delimiter is encountered. .PRINTX is useful for displaying progress through a long assembly or for displaying the value of conditional assembly switches. For example:

```
IF      CPM  
.PRINTX /CPM version/  
ENDIF
```

NOTE

.PRINTX will output on both passes. If only one printout is desired, use the IF1 or IF2 pseudo-op.

1.5.21 .RADIX

`.RADIX <exp>`

The default base (or radix) for all constants is decimal. The `.RADIX` statement allows the default radix to be changed to any base in the range 2 to 16. For example:

```
LXI    H,0FFH
.RADIX 16
LXI    H,0FF
```

The two LXIs in the example are identical. The `<exp>` in a `.RADIX` statement is always in decimal radix, regardless of the current radix.

1.5.22 .REQUEST

`.REQUEST <filename>[,<filename>...]`

`.REQUEST` sends a request to the LINK-80 loader to search the filenames in the list for undefined globals before searching the FORTRAN library. The filenames in the list should be in the form of legal MACRO-80 symbols. They should not include filename extensions or disk specifications. The LINK-80 loader will supply its default extension and will assume the currently selected disk drive.

1.5.23 .Z80

`.Z80` enables the assembler to accept Z80 opcodes. This is the default condition. Z80 mode may also be set by appending the Z switch to the MACRO-80 command string -- see Section 1.1.2.

1.5.24 .8080

`.8080` enables the assembler to accept 8080 opcodes. 8080 mode may also be set by appending the I switch to the MACRO-80 command string -- see Section 1.1.2.

1.5.25 Conditional Pseudo Operations

The conditional pseudo operations are:

IF/IFT <exp>	True if <exp> is not 0.
IFE/IFF <exp>	True if <exp> is 0.
IF1	True if pass 1.
IF2	True if pass 2.
IFDEF <symbol>	True if <symbol> is defined or has been declared External.
IFNDEF <symbol>	True if <symbol> is undefined or not declared External.
IFB <arg>	True if <arg> is blank. The angle brackets around <arg> are required.
IFNB <arg>	True if <arg> is not blank. Used for testing when dummy parameters are supplied. The angle brackets around <arg> are required.

All conditionals use the following format:

```

IFxx    [argument]
.
.
.
[ELSE
.
.
.    ]
ENDIF

```

Conditionals may be nested to any level. Any argument to a conditional must be known on pass 1 to avoid V errors and incorrect evaluation. For IF, IFT, IFF, and IFE the expression must involve values which were previously defined and the expression must be absolute. If the name is defined after an IFDEF or IFNDEF, pass 1 considers the name to be undefined, but it will be defined on pass 2.

ELSE

Each conditional pseudo operation may optionally be used with the ELSE pseudo operation which allows alternate code to be generated when the opposite condition exists. Only one ELSE is permitted for a

given IF, and an ELSE is always bound to the most recent, open IF. A conditional with more than one ELSE or an ELSE without a conditional will cause a C error.

ENDIF

Each IF must have a matching ENDIF to terminate the conditional. Otherwise, an 'Unterminated conditional' message is generated at the end of each pass. An ENDIF without a matching IF causes a C error.

1.5.26 Listing Control Pseudo Operations

Output to the listing file can be controlled by two pseudo-ops:

`.LIST` and `.XLIST`

If a listing is not being made, these pseudo-ops have no effect. `.LIST` is the default condition. When a `.XLIST` is encountered, source and object code will not be listed until a `.LIST` is encountered.

The output of cross reference information is controlled by `.CREF` and `.XCREF`. If the cross reference facility (see Section 1.12) has not been invoked, `.CREF` and `.XCREF` have no effect. The default condition is `.CREF`. When a `.XCREF` is encountered, no cross reference information is output until `.CREF` is encountered.

The output of MACRO/REPT/IRP/IRPC expansions is controlled by three pseudo-ops: `.LALL`, `.SALL`, and `.XALL`. `.LALL` lists the complete macro text for all expansions. `.SALL` lists only the object code produced by a macro and not its text. `.XALL` is the default condition; it is similar to `.SALL`, except a source line is listed only if it generates object code.

1.5.27 Relocation Pseudo Operations

The ability to create relocatable modules is one of the major features of MACRO-80. Relocatable modules offer the advantages of easier coding and faster testing, debugging and modifying. In addition, it is possible to specify segments of assembled code that will later be loaded into RAM (the Data Relative segment) and ROM/PROM (the Code Relative segment). The pseudo operations that

select relocatable areas are CSEG and DSEG. The ASEG pseudo-op is used to generate non-relocatable (absolute) code. The COMMON pseudo-op creates a common data area for every COMMON block that is named in the program.

The default mode for the assembler is Code Relative. That is, assembly begins with a CSEG automatically executed and the location counter in the Code Relative mode, pointing to location 0 in the Code Relative segment of memory. All subsequent instructions will be assembled into the Code Relative segment of memory until an ASEG or DSEG or COMMON pseudo-op is executed. For example, the first DSEG encountered sets the location counter to location zero in the Data Relative segment of memory. The following code is assembled in the Data Relative mode, that is, it is assigned to the Data Relative segment of memory. If a subsequent CSEG is encountered, the location counter will return to the next free location in the Code Relative segment and so on.

The ASEG, DSEG, CSEG pseudo-ops never have operands. If you wish to alter the current value of the location counter, use the ORG pseudo-op.

ORG Pseudo-op

At any time, the value of the location counter may be changed by use of the ORG pseudo-op. The form of the ORG statement is:

```
ORG    <exp>
```

where the value of <exp> will be the new value of the location counter in the current mode. All names used in <exp> must be known on pass 1 and the value of <exp> must be either Absolute or in the current mode of the location counter. For example, the statements

```
DSEG
ORG    50
```

set the Data Relative location counter to 50, relative to the start of the Data Relative segment of memory.

LINK-80

The LINK-80 linking loader (see Section 2 of this manual) combines the segments and creates each relocatable module in memory when the program is loaded. The origins of the relocatable segments are not fixed until the program is loaded and the origins are assigned by LINK-80. The command to

LINK-80 may contain user-specified origins through the use of the -P (for Code Relative) and -D (for Data and COMMON segments) switches.

For example, a program that begins with the statements

```
ASEG
ORG    800H
```

and is assembled entirely in Absolute mode will always load beginning at 800 unless the ORG statement is changed in the source file. However, the same program, assembled in Code Relative mode with no ORG statement, may be loaded at any specified address by appending the -P:<address> switch to the LINK-80 command string.

1.5.28 Relocation Before Loading

Two pseudo-ops, .PHASE and .DEPHASE, allow code to be located in one area, but executed only at a different, specified area.

For example:

```
0000'      .PHASE 100H
0100      CD 0106      FOO:      CALL      BAZ
0103      C3 0007'      JMP        ZOO
0106      C9           BAZ:      RET
                        .DEPHASE
0007'      C3 0005      ZOO:      JMP        5
```

All labels within a .PHASE block are defined as the absolute value from the origin of the phase area. The code, however, is loaded in the current area (i.e., from 0' in this example). The code within the block can later be moved to 100H and executed.

1.6 Macros and Block Pseudo Operations

The macro facilities provided by MACRO-80 include three repeat pseudo operations: repeat (REPT), indefinite repeat (IRP), and indefinite repeat character (IRPC). A macro definition operation (MACRO) is also provided. Each of these four macro operations is terminated by the ENDM pseudo operation.

1.6.1 Terms

For the purposes of discussion of macros and block

operations, the following terms will be used:

1. <dummy> is used to represent a dummy parameter. All dummy parameters are legal symbols that appear in the body of a macro expansion.
2. <dummylist> is a list of <dummy>s separated by commas.
3. <arglist> is a list of arguments separated by commas. <arglist> must be delimited by angle brackets. Two angle brackets with no intervening characters (<>) or two commas with no intervening characters enter a null argument in the list. Otherwise an argument is a character or series of characters terminated by a comma or >. With angle brackets that are nested inside an <arglist>, one level of brackets is removed each time the bracketed argument is used in an <arglist>. (See example, Section 1.6.5.) A quoted string is an acceptable argument and is passed as such. Unless enclosed in brackets or a quoted string, leading and trailing spaces are deleted from arguments.
4. <paramlist> is used to represent a list of actual parameters separated by commas. No delimiters are required (the list is terminated by the end of line or a comment), but the rules for entering null parameters and nesting brackets are the same as described for <arglist>. (See example, Section 1.6.5.)

1.6.2 REPT-ENDM

```
REPT    <exp>
      .
      .
      .
ENDM
```

The block of statements between REPT and ENDM is repeated <exp> times. <exp> is evaluated as a 16-bit unsigned number. If <exp> contains any external or undefined terms, an error is generated. Example:

```
SET     0
REPT    10      ;generates DB1-DB10
SET     X+1
DB      X
ENDM
```


1.6.3 IRP-ENDM

```
IRP    <dummy>,<arglist>
      .
      .
      .
ENDM
```

The <arglist> must be enclosed in angle brackets. The number of arguments in the <arglist> determines the number of times the block of statements is repeated. Each repetition substitutes the next item in the <arglist> for every occurrence of <dummy> in the block. If the <arglist> is null (i.e., <>), the block is processed once with each occurrence of <dummy> removed. For example:

```
IRP    X,<1,2,3,4,5,6,7,8,9,10>
DB     X
ENDM
```

generates the same bytes as the REPT example.

1.6.4 IRPC-ENDM

```
IRPC   <dummy>,string (or <string>)
      .
      .
      .
ENDM
```

IRPC is similar to IRP but the arglist is replaced by a string of text and the angle brackets around the string are optional. The statements in the block are repeated once for each character in the string. Each repetition substitutes the next character in the string for every occurrence of <dummy> in the block. For example:

```
IRPC   X,0123456789
DB     X+1
ENDM
```

generates the same code as the two previous examples.

1.6.5 MACRO

Often it is convenient to be able to generate a given sequence of statements from various places in a program, even though different parameters may be required each time the sequence is used. This capability is provided by the MACRO statement. The form is

```
<name> MACRO <dummylist>
      .
      .
      .
    ENDM
```

where <name> conforms to the rules for forming symbols. <name> is the name that will be used to invoke the macro. The <dummy>s in <dummylist> are the parameters that will be changed (replaced) each time the MACRO is invoked. The statements before the ENDM comprise the body of the macro. During assembly, the macro is expanded every time it is invoked but, unlike REPT/IRP/IRPC, the macro is not expanded when it is encountered.

The form of a macro call is

```
<name> <paramlist>
```

where <name> is the name supplied in the MACRO definition, and the parameters in <paramlist> will replace the <dummy>s in the MACRO <dummylist> on a one-to-one basis. The number of items in <dummylist> and <paramlist> is limited only by the length of a line. The number of parameters used when the macro is called need not be the same as the number of <dummy>s in <dummylist>. If there are more parameters than <dummy>s, the extras are ignored. If there are fewer, the extra <dummy>s will be made null. The assembled code will contain the macro expansion code after each macro call.

NOTE

A dummy parameter in a MACRO/REPT/IRP/IRPC is always recognized exclusively as a dummy parameter. Register names such as A and B will be changed in the expansion if they were used as dummy parameters.

Here is an example of a MACRO definition that defines a macro called FOO:

```

      FOO      MACRO  X
      Y        SET   0
                REPT   X
      Y        SET   Y+1
                DB     Y
                ENDM
                ENDM

```

This macro generates the same code as the previous three examples when the call

```
      FOO      10
```

is executed.

Another example, which generates the same code, illustrates the removal of one level of brackets when an argument is used as an arglist:

```

      FOO      MACRO  X
                IRP    Y,<X>
                DB     Y
                ENDM
                ENDM

```

When the call

```
      FOO      <1,2,3,4,5,6,7,8,9,10>
```

is made, the macro expansion looks like this:

```

      IRP      Y,<1,2,3,4,5,6,7,8,9,10>
      DB       Y
      ENDM

```

1.6.6 ENDM

Every REPT, IRP, IRPC and MACRO pseudo-op must be terminated with the ENDM pseudo-op. Otherwise, the 'Unterminated REPT/IRP/IRPC/MACRO' message is generated at the end of each pass. An unmatched ENDM causes an O error.

1.6.7 EXITM

The EXITM pseudo-op is used to terminate a REPT/IRP/IRPC or MACRO call. When an EXITM is executed, the expansion is exited immediately and any remaining expansion or repetition is not generated. If the block containing the EXITM is nested within another block, the outer level

continues to be expanded.

1.6.8 LOCAL

LOCAL <dummylist>

The LOCAL pseudo-op is allowed only inside a MACRO definition. When LOCAL is executed, the assembler creates a unique symbol for each <dummy> in <dummylist> and substitutes that symbol for each occurrence of the <dummy> in the expansion. These unique symbols are usually used to define a label within a macro, thus eliminating multiply-defined labels on successive expansions of the macro. The symbols created by the assembler range from ..0001 to ..FFFF. Users will therefore want to avoid the form ..nnnn for their own symbols. If LOCAL statements are used, they must be the first statements in the macro definition.

1.6.9 Special Macro Operators and Forms

- & The ampersand is used in a macro expansion to concatenate text or symbols. A dummy parameter that is in a quoted string will not be substituted in the expansion unless it is immediately preceded by &. To form a symbol from text and a dummy, put & between them. For example:

```
ERRGEN MACRO X
ERROR&X:PUSH B
      MVI B,'&X'
      JMP ERROR
      ENDM
```

In this example, the call ERRGEN A will generate:

```
ERRORA: PUSH B
      MVI B,'A'
      JMP ERROR
```

- ;; In a block operation, a comment preceded by two semicolons is not saved as part of the expansion (i.e., it will not appear on the listing even under .LALL). A comment preceded by one semicolon, however, will be preserved and appear in the expansion.

- ! When an exclamation point is used in an argument, the next character is entered literally (i.e., !; and <;> are equivalent).

NUL NUL is an operator that returns true if its argument (a parameter) is null. The remainder of a line after NUL is considered to be the argument to NUL. The conditional

IF NUL argument

is false if, during the expansion, the first character of the argument is anything other than a semicolon or carriage return. It is recommended that testing for null parameters be done using the IFB and IFNB conditionals.

1.7 Using 280 Pseudo-ops

The following 280 pseudo-ops are valid. The function of each pseudo-op is equivalent to that of its 8080 counterpart.

<u>280 pseudo-op</u>	<u>Equivalent 8080 pseudo-op</u>
COND	IFT
ENDC	ENDIF
*EJECT	PAGE
DEFB	DB
DEFS	DS
DEFW	DW
DEFM	DB
DEFL	SET
GLOBAL	PUBLIC
EXTERNAL	EXTRN

The formats, where different, conform to the 8080 format. That is, DEFB and DEFW are permitted a list of arguments (as are DB and DW), and DEFM is permitted a string or numeric argument (as is DB).

1.8 Sample Assembly

DOS READY

M80

*EXMPL1,TTY:=EXMPL1

MAC80 3.2

PAGE

1

0000'	7E	00100	;CSL3(P1,P2)
0001'	23	00200	;SHIFT P1 LEFT CIRCULARLY 3 BITS
0002'	66	00300	;RETURN RESULT IN P2
0003'	6F	00400	ENTRY CSL3
		00450	;GET VALUE OF FIRST PARAMETER
		00500	CSL3:
		00600	MOV A,M
		00700	INX H
		00800	MOV H,M
		00900	MOV L,A
		01000	;SHIFT COUNT
0004'	06 03	01100	MVI B,3
0006'	AF	01200	LOOP: XRA A
		01300	;SHIFT LEFT
0007'	29	01400	DAD H
		01500	;ROTATE IN CY BIT
0008'	17	01600	RAL
0009'	85	01700	ADD L
000A'	6F	01800	MOV L,A
		01900	;DECREMENT COUNT
000B'	05	02000	DCR B
		02100	;ONE MORE TIME
000C'	C2 0006'	02200	JNZ LOOP
000F'	EB	02300	XCHG
		02400	;SAVE RESULT IN SECOND PARAMETER
0010'	73	02500	MOV M,E
0011'	23	02600	INX H
0012'	72	02700	MOV M,D
0013'	C9	02800	RET
		02900	END

MAC80 3.2

PAGE

S

CSL3 0000I' LOOP 0006'

No Fatal error(s)

1.9 MACRO-80 Errors

MACRO-80 errors are indicated by a one-character flag in column one of the listing file. If a listing file is not being printed on the terminal, each erroneous line is also printed or displayed on the terminal. Below is a list of the MACRO-80 Error Codes:

- A Argument error
Argument to pseudo-op is not in correct format or is out of range (.PAGE 1; .RADIX 1; PUBLIC 1; STAX H; MOV M,M; INX C).
- C Conditional nesting error
ELSE without IF, ENDIF without IF, two ELSEs on one IF.
- D Double Defined symbol
Reference to a symbol which is multiply defined.
- E External error
Use of an external illegal in context (e.g., FOO SET NAME##; MVI A,2-NAME##).
- M Multiply Defined symbol
Definition of a symbol which is multiply defined.
- N Number error
Error in a number, usually a bad digit (e.g., 8Q).
- O Bad opcode or objectionable syntax
ENDM, LOCAL outside a block; SET, EQU or MACRO without a name; bad syntax in an opcode (MOV A:); or bad syntax in an expression (mismatched parenthesis, quotes, consecutive operators, etc.).
- P Phase error
Value of a label or EQU name is different on pass 2.
- Q Questionable
Usually means a line is not terminated properly. This is a warning error (e.g. MOV A,B,).
- R Relocation
Illegal use of relocation in expression, such as abs-rel. Data, code and COMMON areas are relocatable.

- U Undefined symbol
 A symbol referenced in an expression is not defined. (For certain pseudo-ops, a V error is printed on pass 1 and a U on pass 2.)
- V Value error
 On pass 1 a pseudo-op which must have its value known on pass 1 (e.g., .RADIX, .PAGE, DS, IF, IFE, etc.), has a value which is undefined. If the symbol is defined later in the program, a U error will not appear on the pass 2 listing.

Error Messages:

- 'No end statement encountered on input file'
 No END statement: either it is missing or it is not parsed due to being in a false conditional, unterminated IRP/IRPC/REPT block or terminated macro.
- 'Unterminated conditional'
 At least one conditional is unterminated at the end of the file.
- 'Unterminated REPT/IRP/IRPC/MACRO'
 At least one block is unterminated.
- [xx] [No] Fatal error(s) [,xx warnings]
 The number of fatal errors and warnings. The message is listed on the CRT and in the list file.

1.10 Compatibility with Other Assemblers

The \$EJECT and \$TITLE controls are provided for compatibility with INTEL's ISIS assembler. The dollar sign must appear in column 1 only if spaces or tabs separate the dollar sign from the control word. The control

\$EJECT

is the same as the MACRO-80 PAGE pseudo-op.
 The control

\$TITLE('text')

is the same as the MACRO-80 SUBTTL <text> pseudo-op.

The INTEL operands PAGE and INPAGE generate Q errors when used with the MACRO-80 CSEG or DSEG

pseudo-ops. These errors are warnings; the assembler ignores the operands.

When MACRO-80 is entered, the default for the origin is Code Relative 0. With the INTEL ISIS assembler, the default is Absolute 0.

With MACRO-80, the dollar sign (\$) is a defined constant that indicates the value of the location counter at the start of the statement. Other assemblers may use a decimal point or an asterisk. Other constants are defined by MACRO-80 to have the following values:

A=7	B=0	C=1	D=2	E=3
H=4	L=5	M=6	SP=6	PSW=6

1.11 Format of Listings

On each page of a MACRO-80 listing, the first two lines have the form:

```
[TITLE text]      MAC80 3.2      PAGE x[-y]
[SUBTTL text]
```

where:

1. TITLE text is the text supplied with the TITLE pseudo-op, if one was given in the source program.
2. x is the major page number, which is incremented only when a form feed is encountered in the source file. (When using Microsoft's EDIT-80 text editor, a form feed is inserted whenever a page mark is done.) When the symbol table is being printed, x = 'S'.
3. y is the minor page number, which is incremented whenever the .PAGE pseudo-op is encountered in the source file, or whenever the current page size has been filled.
4. SUBTTL text is the text supplied with the SUBTTL pseudo-op, if one was given in the source program.

Next, a blank line is printed, followed by the first line of output.

A line of output on a MACRO-80 listing has the following form:

```
[crf#]      [error] loc#m      xx      xxxx ...      source
```

If cross reference information is being output, the first item on the line is the cross reference number, followed by a tab.

A one-letter error code followed by a space appears next on the line, if the line contains an error. If there is no error, a space is printed. If there is no cross reference number, the error code column is the first column on the listing.

The value of the location counter appears next on the line. It is a 4-digit hexadecimal number of 6-digit octal number, depending on whether the -O or -H switch was given in the MACRO-80 command string.

The character at the end of the location counter value is the mode indicator. It will be one of the following symbols:

'	Code Relative
"	Data Relative
!	COMMON Relative
<space>	Absolute
*	External

Next, three spaces are printed followed by the assembled code. One-byte values are followed by a space. Two-byte values are followed by a mode indicator. Two-byte values are printed in the opposite order they are stored in, i.e., the high order byte is printed first. Externals are either the offset or the value of the pointer to the next External in the chain.

The remainder of the line contains the line of source code, as it was input.

1.11.1 Symbol Table Listing

In the symbol table listing, all the macro names in the program are listed alphabetically, followed by all the symbols in the program, listed alphabetically. After each symbol, a tab is printed, followed by the value of the symbol. If the symbol is Public, an I is printed immediately after the value. The next character printed will be one of the following:

U Undefined symbol.

C COMMON block name. (The "value" of the
COMMON block is its length (number of
bytes) in hexadecimal or octal.)

* External symbol.

<space> Absolute value.

' Program Relative value.

" Data Relative value.

! COMMON Relative value.

1.12 Cross Reference Facility

The Cross Reference Facility is invoked by typing CREF80 at TRSDOS command level. In order to generate a cross reference listing, the assembler must output a special listing file with embedded control characters. The MACRO-80 command string tells the assembler to output this special listing file. (See Section 1.5.26 for the .CREF and .XCREF pseudo-ops.) -C is the cross reference switch. When the -C switch is encountered in a MACRO-80 command string, the assembler opens a /CRF file instead of a /LST file.

Examples:

*=TEST-C	Assemble file TEST/MAC and create object file TEST/REL and cross reference file TEST/CRF.
*T,U=TEST-C	Assemble file TEST/MAC and create object file T/REL and cross reference file U/CRF.

When the assembler is finished, it is necessary to call the cross reference facility by typing CREF80. (CREF80 is on diskette #1) CREF80 command format is:

*listing file=source file

The default extension for the source file is /CRF. the -L switch is ignored, and any other switch will cause an error message to be sent to the terminal. Possible command strings are:

*=TEST	Examine file TEST/CRF and generate a cross reference listing file TEST/LST.
*T=TEST	Examine file TEST/CRF and generate a cross reference listing file T/LST.

Cross reference listing files differ from ordinary listing files in that:

1. Each source statement is numbered with a cross reference number.
2. At the end of the listing, variable names appear in alphabetic order along with the numbers of the lines on which they are referenced or defined. Line numbers on which the symbol is defined are flagged with '#'.

SECTION 2

LINK-80 Linking Loader

The LINK-80 Linking Loader takes the relocatable object files generated by the FORTRAN compiler and MACRO-80 assembler and loads them into memory in a form that can be executed. In addition, LINK-80 automatically searches the system library (FORLIB) and loads the library routines needed to satisfy any undefined global references (i.e., calls generated by the compiled program to subroutines in the system library).

LINK-80 provides the user with several loading options. Programs may be loaded at user-specified locations, and program areas and data areas may be separated in memory. A memory image of the executable file produced by LINK-80 can be written to disk. The default extension for the name of the executable file is /CMD.

2.1 Running LINK-80

When you give TRSDOS the command

L80

(diskette #2 must be in the disk drive), you are running the LINK-80 linking loader. When the loader is ready to accept commands, it prompts the user with an asterisk. The loader will exit back to TRSDOS after a command containing an E or G switch (see Section 2.1.1), or after a <break> is done at command level.

Command lines are also supported by LINK-80.

2.1.1 LINK-80 Commands

A command to LINK-80 consists of a string of filenames and/or switches. The command format is:

[filename1][-switch1][,filename2][-switch2]...

All filenames must be in TRSDOS filename format.

After LINK-80 receives the command, it will load or search (see the S switch) the specified files. Then it will list all the symbols that remained undefined, with each followed by an asterisk.

Example:

*MAIN

DATA 5200 5300

SUBR1* (SUBR1 is undefined)

DATA 5200 5300

*SUBR1

*-G (Starts Execution - see below)

Typically, to execute a FORTRAN program and subroutines, the user types the list of filenames followed by -G (begin execution). Before execution begins, LINK-80 will always search the system library (FORLIB/REL) to satisfy any unresolved external references. If you wish to first search libraries of your own, append the filenames that are followed by -S to the end of the loader command string.

2.1.2 LINK-80 Switches

A number of switches may be given in the LINK-80 command string to specify actions affecting the loading process. Each switch must be preceded by a dash (-). These switches are:

<u>Switch</u>	<u>Action</u>
Reset (Break)	Reset. Put loader back in its initial state. Use -R if you loaded the wrong file by mistake and want to restart. -R takes effect as soon as it is encountered in a command string.
E or E:Name	Exit LINK-80 and return to the Operating System. The system library will be searched on the current disk to satisfy any existing undefined globals. The optional form E:Name (where Name is a global symbol previously defined in one of the modules) uses Name for the start address of the program. Use -E to load a program and exit back to the monitor.
G or G:Name	Start execution of the program as soon as the current command line has been interpreted. The system

library will be searched on the current disk to satisfy any existing undefined globals. Before execution actually begins, LINK-80 prints two numbers and a BEGIN EXECUTION message. The two numbers are the start address and the address of the next available byte. The optional form G:Name (where Name is a global symbol previously defined in one of the modules) uses Name for the start address of the program.

N

If a <filename>-N is specified, the program will be saved on disk under the selected name (with a default extension of CMD) when a -E or -G is done.

P and D

-P and -D allow the origin(s) to be set for the next program loaded. -P and -D take effect when seen (not deferred), and they have no effect on programs already loaded. The form is -P:<address> or -D:<address>, where <address> is the desired origin in the current typeout radix. (Default radix is hexadecimal. -O sets radix to octal; -H to hex.) LINK-80 does a default -P:<link origin> (i.e., 5200).

If no -D is given, data areas are loaded before program areas for each module. If a -D is given, all Data and Common areas are loaded starting at the data origin and the program area at the program origin. Example:

```
*-P:200,FOO
Data      200      300
*-R
*-P:200 -D:400,FOO
Data      400      480
Program 200      280
```

U

List the origin and end of the program and data area and all undefined globals as soon as the current command line has been interpreted. The program informa-

tion is only printed if a -D has been done. Otherwise, the program is stored in the data area.

M List the origin and end of the program and data area, all defined globals and their values, and all undefined globals followed by an asterisk. The program information is only printed if a -D has been done. Otherwise, the program is stored in the data area.

S Search the filename immediately preceding the -S in the command string to satisfy any undefined globals.

Examples:

*-M List all globals

*MYPROG,SUBROT,MYLIB-S

Load MYPROG.REL and SUBROT.REL and then search MYLIB.REL to satisfy any remaining undefined globals.

*-G Begin execution of main program

2.2 Sample Link

```
DOS READY
L80
*EXAMPL,EXMPL1-G
DATA 5200 52AC
[5200 52AC]
[BEGIN EXECUTION]
```

1792	14336
14336	-16383
-16383	14
14	112
112	896
DOS READY	

2.3 Format of LINK Compatible Object Files

NOTE

Section 2.3 is reference material for users who wish to know the load format of LINK-80 relocatable object files. Most users will want to skip this section, as it does not contain material necessary to the operation of the package.

LINK-compatible object files consist of a bit stream. Individual fields within the bit stream are not aligned on byte boundaries, except as noted below. Use of a bit stream for relocatable object files keeps the size of object files to a minimum, thereby decreasing the number of disk reads/writes.

There are two basic types of load items: Absolute and Relocatable. The first bit of an item indicates one of these two types. If the first bit is a 0, the following 8 bits are loaded as an absolute byte. If the first bit is a 1, the next 2 bits are used to indicate one of four types of relocatable items:

- | | |
|----|---|
| 00 | Special LINK item (see below). |
| 01 | Program Relative. Load the following 16 bits after adding the current Program base. |
| 10 | Data Relative. Load the following 16 bits after adding the current Data base. |
| 11 | Common Relative. Load the following 16 bits after adding the current Common base. |

Special LINK items consist of the bit stream 100 followed by:

a four-bit control field

an optional A field consisting of a two-bit address type that is the same as the two-bit field above except 00 specifies absolute address

an optional B field consisting

of 3 bits that give a symbol
length and up to 8 bits for
each character of the symbol

A general representation of a special LINK item is:

1 00 xxxx	yy nn	zzz + characters of symbol name
-----		-----
	A field	B field

xxxx	Four-bit control field (0-15 below)
yy	Two-bit address type field
nn	Sixteen-bit value
zzz	Three-bit symbol length field

The following special types have a B-field only:

0	Entry symbol (name for search)
1	Select COMMON block
2	Program name
3	Request library search
4	Reserved for future expansion

The following special LINK items have both an A field and a B field:

5	Define COMMON size
6	Chain external (A is head of address chain, B is name of external symbol)
7	Define entry point (A is address, B is name)
8	Reserved for future expansion

The following special LINK items have an A field only:

9	External + offset. The A value will be added to the two bytes starting at the current location counter immediately before execution.
10	Define size of Data area (A is size)
11	Set loading location counter to A
12	Chain address. A is head of chain, replace all entries in chain with current location counter. The last entry in the chain has an address field of absolute zero.
13	Define program size (A is size)
14	End program (forces to byte boundary)

The following special Link item has neither an A nor a B field:

15	End file
----	----------

2.4 LINK-80 Error Messages

LINK-80 has the following error messages:

?No Start Address	A -G switch was issued, but no main program had been loaded.
?Loading Error	The last file given for input was not a properly formatted LINK-80 object file.
?Out of Memory	Not enough memory to load program.
?Command Error	Unrecognizable LINK-80 command.
?<file> Not Found	<file>, as given in the command string, did not exist.
%2nd COMMON Larger /XXXXXX/	The first definition of COMMON block /XXXXXX/ was not the largest definition. Re- order module loading sequence or change COMMON block definitions.
%Mult. Def. Global YYYYYY	More than one definition for the global (internal) symbol YYYYYY was encountered during the loading process.
%Overlaying [Program] [Data]	Area [,Start = xxxx [,Public = <symbol name>(xxxx) [,External = <symbol name>(xxxx)] A -D or -P will cause already loaded data to be destroyed.
?Intersecting [Program] [Data]	Area The program and data area intersect and an address or external chain entry is in this intersection. The final value cannot be con- verted to a current value since it is in the area intersection.

?Start Symbol - <name> - Undefined

After a -E: or -G: is given,
the symbol specified was not
defined.

Origin ☐ Above ☐ Below Loader Memory, Move Anyway (Y or N)?

After a -E or -G was given,
either the data or program
area has an origin or top
which lies outside loader
memory (i.e., loader origin
to top of memory). If a
Y <cr> is given, LINK-80
will move the area and con-
tinue. If anything else is
given, LINK-80 will exit.
In either case, if a -N was
given, the image will already
have been saved.

?Can't Save Object File

A disk error occurred when
the file was being saved.

2.5 Program Break Information

LINK-80 stores the address of the first free
location in a global symbol called \$MEMORY if that
symbol has been defined by a program loaded.
\$MEMORY is set to the top of the data area +1.

NOTE

If -D is given and the data origin is less
than the program area, the user must be
sure there is enough room to keep the
program from being destroyed. This is
particularly true with the disk driver for
FORTRAN-80 which uses \$MEMORY to allocate
disk buffers and FCB's.

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